THE BRITISH SOCIETY FOR THE PROMOTION OF VEGETABLE RESEARCH

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Eighth Annual Report

1957

(OCT. 1956 - SEPT. 1957)

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NATIONAL VEGETABLE RESEARCH STATION

WELLESBOURNE - - WARWICK

Telephone : Wellesbourne 382 (3 lines)

1958

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THE CONSTITUTION OF THE NATIONAL VEGETABLE RESEARCH STATION

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a Governing Body incorporated on 28th September 1949, as a company limited by guarantee, not having a share capital, and having the title 'The British Society for the Promotion of Vegetable Research', with its registered office at Wellesbourne.

The members of the Governing Body, twenty-three in number, include nominees of the two Agricultural Departments of Great Britain, of the Department of Scientific and Industrial Research, of various learned societies, universities and institutions concerned with horticulture, of vegetable producers (through the National Farmers' Unions of the two countries and the National Allotments and Gardens Society) and of trade interests.

The properties at Wellesbourne and Paglesham are leased to the Society by the Ministry of Agriculture, Fisheries and Food. Until 31st March 1956, the Society depended for its funds on grants from this Ministry who were advised by the Agricultural Research Council (A.R.C.) regarding research work and staff. On 1st April 1956, the grant-aiding functions of the Ministry were transferred to the A.R.C. If the Society establishes stations or conducts work in Scotland, grants will be receivable from the Scottish Agricultural Advisory Council who will be advised by the A.R.C.

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Minister of Agriculture, Fisheries and Food :

Professor K. MATHER, C.B.E., D.Sc., F.R.S., Department of Genetics, The University, Edgbaston, Birmingham, 15.

W. J. F. SOPER, Esq., J.P., New Hall Farm, Harlow, Essex. (From 7/6/1957).

H. V. TAYLOR, Esq., C.B.E., D.Sc., A.R.C.S., V.M.H. (Chairman), Preston Grange, Barnet Road, Potters Bar, Middlesex. (Until 6/6/1957).

Professor P. T. THOMAS, B.Sc., Ph.D., Department of Agricultural Botany, The Institute of Rural Science, University College of Wales, Penglais, Aberystwyth.

Professor C. W. WARDLAW, Ph.D., D.Sc., F.R.S.E., Department of Cryptogamic Botany, The University, Manchester, 13.

Appointed by the Secretary of State for Scotland :

R. L. SCARLETT, Esq., C.B.E., C.D.A., Sweethope, Musselburgh, Midlothian.

Appointed by the Department of Scientific and Industrial Research :

R. G. TOMKINS, Esq., M.A., Ph.D., Ditton Laboratory, Larkfield, Maidstone, Kent.

Appointed by the University of London :

Professor J. W. MUNRO, C.B.E., M.A., D.Sc., Frognall Cottage, Sunninghill, Berks.

Appointed by the University of Reading :

Professor R. H. STOUGHTON, D.Sc., A.R.C.S., V.M.H., Department of Horticulture, The University, Reading. (Until 20/9/1957).

Appointed by the University of Cambridge :

J. BARKER, Esq., M.A., Ph.D., F.R.S., The Botany School, Downing Street, Cambridge.

Appointed by the University of Bristol :

Professor T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S., 'Redwings', Old Church Road, Nailsea, Somerset.

Appointed by the University of Edinburgh :

ALEXANDER NELSON, Esq., Ph.D., D.Sc., F.R.S.E., University Department of Botany, at Royal Botanic Garden, Edinburgh, 3.

Appointed by the Royal Society :

Professor W. BROWN, M.A., D.Sc., F.R.S., The Bush, Haddenham, Aylesbury, Bucks.

Appointed by the John Innes Horticultural Institution :

K. S. DODDS, Esq., Ph.D., D.Sc., Bayfordbury, Herts.

Appointed by the National Farmers' Union :

A. H. BOARDMAN, Esq., A.M.I.B.A.E., Lunts Farm, Paglesham, Rochford, Essex.
A. A. CLUCAS, Esq., Red Trees, Lathom, Ormskirk, Lancs.
G. G. HOLE, Esq., Pakyns, Hurstpierpoint, Sussex.
J. LAITY, Esq., Polkinghorne, Gwinear, Hayle, Cornwall.
W. F. SWIFT, Esq., Avon Cottage, Fladbury, Pershore, Worcs.

Appointed by the National Farmers' Union of Scotland :

DAVID LOWE, Esq., C.B.E., Elvingston, Gladsmuir, East Lothian. (Chairman from 7/6/1957).

Appointed by the Horticultural Trades' Association :

J. S. W. CRACKNELL, Esq., V.M.H., c/o Watkins and Simpson Ltd., 26-29 Drury Lane, London, W.C.2.

Appointed by the Royal Horticultural Society :

R. E. THODAY, Esq., A.H., R.H.S., St. John's College Gardens, 18 Madingley Road, Cambridge.

Appointed by the National Allotments and Gardens Society :

Professor J. CALDWELL, Ph.D., D.Sc., Hatherly Biological Laboratories, Prince of Wales Road, Exeter.

Appointed by the Seed Trade Association of the United Kingdom :

F. HOLL, Esq., Harrison and Sons (Leicester) Ltd., St. James' Street, Leicester.

The Executive Committee

Professor W. BROWN
J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq.
J. LAITY, Esq.
DAVID LOWE, Esq. (Chairman until 17/10/1957)
Professor K. MATHER
Professor J. W. MUNRO
Professor R. H. STOUGHTON (Until 20/9/1957)
W. F. SWIFT, Esq.
Professor T. WALLACE (Chairman from 18/10/1957)

Staff and Research Sub-Committee

Professor W. BROWN (Chairman)
A. A. CLUCAS, Esq.
DAVID LOWE, Esq.
Professor K. MATHER
Professor J. W. MUNRO
R. L. SCARLETT, Esq.
Professor R. H. STOUGHTON (Until 20/9/1957)
Dr. H. V. TAYLOR (Until 6/6/1957)
Dr. R. G. TOMKINS
Professor T. WALLACE

Co-opted :

C. E. HUDSON, Esq., C.B.E., N.D.H., V.M.H., Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

Farm Management Sub-Committee

A. H. BOARDMAN, Esq.
J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq.
J. LAITY, Esq.
R. L. SCARLETT, Esq.
W. J. F. SOPER, Esq. (From 6/6/1957)
W. F. SWIFT, Esq. (Chairman)

Co-opted :

E. R. HOARE, Esq., B.Sc. (Eng.), M.I.E.E., National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds. (Until 19/9/1957)

Varieties Inspection Sub-Committee

A. A. CLUCAS, Esq.
J. S. W. CRACKNELL, Esq.
DAVID LOWE, Esq. (Chairman)
G. G. HOLE, Esq.
F. HOLL, Esq.
W. F. SWIFT, Esq.

Co-opted :

C. D. R. DAWSON, Esq., Ph.D., Pyports, Cobham, Surrey.
F. G. POTTER, Esq., Sutton and Sons Ltd., The Royal Seed Establishment, Reading, Berks.

STAFF

Director :

JAMES PHILP, B.Sc. (Glas.), Ph.D. (Lond.).*

Deputy Director :

D. W. WRIGHT. M.A. (Cantab.).*

Plant Breeding : J. C. HAIGH, B.Sc., Ph.D. (Lond.), A.R.C.S., A.I.C.T.A.
H. HOLLAND, B.Sc. (Wales).
A. G. JOHNSON, B.Sc. (Lond.), Ph.D. (Wales).
L. E. WATTS, B.Sc. (Wales).
G. J. FAULKNER.
G. J. FROST, B.Sc. (Dunelm).
R. A. T. GEORGE.
Assistants : Miss C. H. BEARDALL, Dip. Hort. (Nott.).
D. D. CLARKE. (Resigned 30/9/1957).
Miss P. A. DYMOND.
Miss W. HORN.
Miss J. M. H. INSLEY.
I. MITCHELL.
Miss P. M. RUSSELL.
B. WOODWARD. (Appointed 1/10/1957).

Chemistry : F. HAWORTH, B.Sc., Ph.D. (Liverpool), Dip. Ag. Sci. (Cantab.).
S. P. SPRAGG, B.Sc., Ph.D. (Bristol).
Mrs. J. C. HUGHES, B.Sc., Ph.D. (Lond.), D.I.C. (Appointed 22/10/56)
Assistants : P. B. BANHAM. (Resigned 28/2/1957).
Miss M. A. BENNETT.
Miss P. CHANDLER. (Appointed 1/5/1957)
Mrs. A. DAVIES.
Miss E. A. PLATT. (Appointed 3/12/1956)

Physiology : E. J. WINTER, M.C., M.Sc. (Bristol).
J. K. A. BLEASDALE, B.Sc., Ph.D. (Manc.).
R. B. AUSTIN, B.Sc. (Birm.).
Assistants : Miss B. A. FREEMAN. (Appointed 1/10/1957)
Miss P. HURLEY. (Appointed 1/9/1957)

Irrigation : E. J. WINTER, M.C., M.Sc. (Bristol).
P. J. SALTER, M.Sc. Hort., Ph.D. (Nott.).
G. STANHILL, B.Sc., Ph.D. (Reading).
Miss F. L. C. BLACKWALL, B.Sc. Hort. (Lond.), Dip. Hort. (Studley). (Appointed 7/1/1957).
Assistants : B. G. HUNT. (Resigned 14/9/1957)
A. S. MORGANS.
Miss J. I. E. RUBIO.
Miss J. M. SMITH. (Resigned 31/12/1956)
Miss D. BALDOCK. (From 3/1/1957 to 10/8/1957)
Miss J. SIMMS. (From 8/10/1956 to 21/9/1957)
Miss P. A. HODNETT. (Appointed 9/9/1957)
Miss J. BANNAN. (Appointed 16/9/1957)
Miss C. DOWN. (Appointed 23/9/1957)

Entomology : D. W. WRIGHT, M.A. (Cantab.).*
J. A. DUNN, M.Sc. (Dunelm).
G. A. WHEATLEY, B.Sc. (Dunelm).
R. D. HUGHES, B.Sc., Ph.D. (Lond.).
Mrs. D. D. SALTER (née BOWE), B.Sc. (Dunelm).
J. S. BUXTON, B.Sc. Hort. (Nott.).
J. A. HARDMAN, B.Sc. Hort. (Nott.).
Assistants : H. I. SMITH.
Miss G. BUBB. (Appointed 12/8/1957)
Miss J. MARCH.
Miss C. R. MARTIN.
Miss S. PHILLIPS. (Resigned 10/8/1957)
Miss A. SARGENT.

*Recognised lecturer of the University of Birmingham.

Pathology : W. G. KEYWORTH, B.Sc., Ph.D. (Lond.), A.R.C.S., D.I.C.*
A. G. CHANNON, B.Sc. (Aberdeen).
J. A. TOMLINSON, B.Sc., Ph.D. (Birm.).
Mrs. D. E. KNIGHT, B.Sc. (Lond.), M.Sc. Hort. (Nott.), Ph.D. (Lond.), A.R.C.S. (Working under A.R.C. grant—resigned 30/9/1957)
R. B. MAUDE, B.Sc. (Dublin), M.Sc. (Nott.). (Appointed 1/1/1957)
Miss J. S. HOWELL, B.Sc. (Birm.).
Miss B. R. SMITH, B.Sc. Hort. (Lond.).
J. M. WAY, B.Sc. Hort., M.Sc. (Lond.).
M. J. W. WEBB, B.Sc. Hort. (Nott.).
Assistants : Miss J. CARPENTER. (Resigned 28/2/1957)
Miss P. A. DADLEY.
Miss M. P. INSALL.
Miss A. P. WARD, N.D.D.H.
Miss J. TAYLOR. (Appointed 16/9/1957)

Weeds : H. A. ROBERTS, B.Sc. (Manc.).
Miss M. E. SMART, B.Sc. (Lond.).
Assistants : Mrs. I. H. FROST.
Mrs. A. H. T. GEORGE.
Miss U. W. LAURENCE.

Statistics : J. A. NELDER, M.A. (Cantab.).
D. COOKE, B.A. (Oxon.). (Resigned 31/8/1957)
Assistants : Miss S. DOWLER. (Appointed 7/1/1957)
Miss A. MEADUS.
Miss H. E. RUSSELL.

Librarian : Miss B. M. BAGGS, M.Sc. (Liverpool). (Resigned 30/9/1957)
Miss B. M. MOORE, N.D.D.H. (Appointed 1/10/1957)

Photographer : Miss J. KULLMAN.

Farm : *Manager :* T. J. NORWOOD.
Foremen—Wellesbourne : I. F. REYNOLDS.
Paglesham : D. T. McVITTIE.

Administration : *Secretary :* J. C. WILKINS, LL.B. (Lond.), F.C.I.S. (Resigned 30/6/1957)
J. J. HOLLIST, B.Com., LL.B. (Lond.), A.A.C.C.A., A.I.B. (Appointed 1/9/1957)
Accounts Assistant : D. A. BARTLETT.
Administrative Assistant : L. C. FITZGERALD.
Director's Secretary : Miss E. B. FORRESTER.
Clerical Officers : Mrs. J. BLOUNT.
Mrs. J. M. FAULKNER.
Office Assistants : Miss G. E. A. CLACK. (Appointed 1/1/1957)
Mrs. E. M. CLAYTON (From 1/2/1957 to 30/4/1957)
Miss S. M. L. McDONAUGH. (Appointed 26/2/1957)
Miss W. STYLES. (Appointed 1/5/1957)
Miss S. B. TOOKEY. (Resigned 12/1/1957)
Miss M. A. WARR. (Resigned 28/2/1957)

*Recognised lecturer of the University of Birmingham.

Mr. B. Mitchell was seconded by the University of Birmingham in October 1956 to carry out research, under an A.R.C. Research Studentship, in the Entomology Section for a higher degree.

Dr. Paula Pavlek of the University of Zagreb, and Mr. M. Petrovic of the Institute for Vegetable Improvement, near Belgrade, came to Wellesbourne in April 1957, under the U.K. Assistance Programme for Yugoslavia, to work for six months and one year, respectively, in the Plant Breeding Section.

Under the U.K. Sponsoring Authority for the International Exchange of Young Agriculturists, Mr. Hans Michel came to the Station in March 1957 from Germany to obtain one year's experience of vegetable production. Mr. Mons Flönes, on completing a year at Wellesbourne under the same exchange scheme, returned to Norway in April 1957.

REPORT OF THE DIRECTOR

DEVELOPMENT

Work began on the clearing of the site for the two-storey main block of laboratories and offices on 2nd April 1957. Good progress was made and by the end of January 1958 the walls, and roofing and glazing had been completed on all except the portion containing the lecture room and library ; the drainage system had been almost completed ; the heating system had been installed on the ground floor and some of the internal partition walls had been erected.

By the same date, the brick walls, floors and drainage had been completed for a 100 ft. by 30 ft. glasshouse containing twenty compartments for plant breeding work.

The canteen kitchen was enlarged at the expense of two small store rooms which were replaced by the addition of another larger store room. This work was done at the end of 1957 by Station labour.

At Paglesham, a vegetable seed drying shed was constructed of timber with an asbestos roof by our own staff in November 1957.

STAFF

Mr. D. W. Wright was appointed as Deputy Director on 1st April 1957 and will continue as Head of the Entomology Section.

Appointments

Mr. R. B. Maude was appointed as a Scientific Officer in the Pathology Section on 1st January 1957. Previously he was an Assistant Lecturer in botany at the University College of Wales.

Miss F. L. C. Blackwall joined the staff as an Assistant Experimental Officer in the Irrigation Section on 7th January. She had previous experience at Long Ashton Research Station on problems relating to the parthenocarpic development of fruits and the process of abscission.

Dr. J. Clare Hughes, who came from the Department of Applied Entomology of the Imperial College of Science and Technology where she was studying problems related to the control of tsetse flies, was appointed as an Assistant Experimental Officer (Temporary) in the Chemistry Section on 22nd October 1956.

Mr. J. J. Hollist was appointed as Secretary to the Society and the Station on 1st September 1957 in succession to Mr. Wilkins. Mr. Hollist was previously employed as Chief Accountant with the Marine Department of the Nigerian Government.

The following 13 Scientific Assistants were appointed during the year, seven of whom replaced those who had resigned :—

Miss E. A. Platt, Chemistry
Miss S. Dowler, Statistics
Miss P. Chandler, Chemistry
Miss G. Bubb, Entomology
Miss P. Hurley, Physiology
Miss P. A. Hodnett, Irrigation
Miss J. Bannan, Irrigation
Miss J. Taylor, Pathology
Miss C. Down, Irrigation
Miss B. A. Freeman, Physiology
Mr. B. Woodward, Plant Breeding
Miss D. Baldock, Miss J. Simms } Irrigation. Temporary appointments.

Eleven University students were employed during the summer to assist in the research sections.

Miss G. E. A. Clack was appointed as a Clerk/Telephonist on 1st January, and Mrs. E. M. Clayton was employed in a temporary capacity as a Shorthand-Typist from 1st February to 30th April. Miss S. M. L. McDonaugh joined the staff on 26th February as a Clerical Assistant, and Miss W. Styles was appointed as a Shorthand-Typist on 1st May 1957.

Mr. A. C. Outram was appointed as Clerk of Works on 24th April 1957.

Resignations

Mr. D. Cooke resigned on 31st August in order to take up a temporary appointment for one year with the Institute of Statistics, North Carolina, U.S.A. On his return to this country, Mr. Cooke is to take up an appointment at the Glasshouse Crops Research Institute at Rustington.

Dr. D. E. Knight left the Station on 30th September on the expiration of the special A.R.C. grant under which she had been carrying out research on the *Didymella* disease of outdoor tomatoes.

Mr. J. C. Wilkins resigned on 30th June. As the first Secretary to the Society and to the N.V.R.S., from 14th November 1949, Mr. Wilkins played an important part in assisting the Director in the development of the Station.

Miss B. M. Baggs resigned her post as Librarian on 30th September.

Six Scientific Assistants resigned during the year ; Miss J. M. Smith and Miss J. Carpenter left to be married ; Mr. P. B. Banham, Miss S. Phillips and Mr. B. G. Hunt took up positions elsewhere, and Mr. D. D. Clarke resigned on gaining entrance to Hull University.

Miss S. B. Tookey resigned on 12th January 1957 to take up another post, and Miss M. A. Warr resigned on 28th February 1957, on the occasion of her marriage.

We congratulate Mrs. D. E. Knight and Mr. J. M. Way on having been awarded Ph.D. and M.Sc. degrees, respectively, by the University of London. Their theses were based on work which they had carried out at Wellesbourne. A third member of the staff has been accepted by the University of Birmingham as a candidate for a higher degree.

Members of the research staff attended a number of conferences during the year. In October Mr. Wright gave two lectures on 'Problems in economic entomology' to the Department of Zoology, Birmingham University. During November, Dr. Tomlinson gave a talk on 'The control of watercress crook root disease' at a meeting of the Association of Applied Biology and, at the British Weed Control Conference held at Blackpool, Dr. Bleasdale and Mr. Roberts read papers entitled 'Some preliminary observations on the assessment of weed control in row crops' and 'The response of vegetable crops to applications of some phenoxybutyric acids'. Dr. Philp gave a talk on 'Research on vegetables' at the N.I.A.B. Crop Conference which was held in December. Drs. Haigh and Johnson read papers entitled 'Vegetable breeding' and 'Brassica breeding' at a N.A.A.S. Provincial Conference and Refresher Course held in January at Wye. During the same month Mr. Nelder gave two lectures on statistical methods as applied to experiments with vegetables and flowers, as part of a Statistics Course for N.A.A.S. Officers which was held at Rothamsted. He also read three papers on 'Field experiments with perennial crops', 'Variety trials', and 'Statistical theory and experimental data' at the Plant Breeders' Course held in Versailles in February. During March, Dr. Tomlinson spoke on the 'Control of virus and crook root diseases of watercress' at the Spring Conference of the N.F.U. Watercress Branch, held in Salisbury, and Dr. Keyworth, Mr. Wheatley and Mr. Wright attended the A.R.C. Technical Conference on Insecticide and Fungicide Research at Bristol. Dr. Bleasdale gave a talk on 'An automatic day-length cabinet' and Mr. Winter gave two talks on 'Design of glasshouses for research purposes' and 'Equipment for cooling glasshouses' at the Fourth Easter School in Agricultural Science, held at Sutton Bonington in April. Dr. Clare Hughes and Dr. Spragg were present at a two-day Symposium on the Maturation and Germination of Peas, held in Cambridge in June, at which Dr. Philp took the Chair for one session and Dr. Spragg spoke on 'Protein synthesis and respiration of the maturing pea seed'.

The A.R.C. kindly provided a grant to enable Mr. Dunn to attend the Fourth International Conference of Crop Protection held in Hamburg in September.

Mr. Winter was privileged to give the Masters Memorial Lecture of the Royal Horticultural Society when he spoke on 'The watering of field and glasshouse crops in the U.K.'. The lecture was given in two parts, the first in September and the second in November 1957, in London.

The Pathology Section staged an exhibit, in the Scientific Section of the R.H.S. Chelsea Show, illustrating the causal fungus of crook root disease of watercress, its method of attack, and control by the use of zinc frit.

The first social event of the year took the form of a barbecue and dance, held on 9th November 1956. Fine weather contributed greatly to the enjoyment of this very successful evening which was attended by 94 members of staff and their friends. Staff Christmas lunch was served to a record number of 80 on 19th December. Carol singing, accompanied by Dr. Haigh at the piano, followed the excellent meal. The Christmas-New Year party took place in the canteen on 11th January 1957. 120 people were entertained on this enjoyable occasion. On 22nd March a buffet dance was held at the Red Horse Hotel, Stratford-upon-Avon and, although petrol rationing limited the number able to attend to 56, the evening proved to be a most popular venture. A programme of part songs and piano recitals was arranged by Mr. Nelder and, under his direction, the Station choir entertained members of staff and their friends on 29th March. Our thanks are due to them for a very pleasant evening. To conclude the year's social activities, a garden fête followed in the evening by a dance, took place on 20th July. Both functions were well appreciated by all who came to the fête and dance, and particularly keen enthusiasm was displayed by the children during the afternoon.

Our thanks are due to Miss Kullman, Miss March, Miss Ward, Mr. Wright (Chairman), Mr. Holland (Treasurer) and Dr. Spragg (Secretary), who comprised the Sports and Social Committee, for organising the four social events during the year and to all those members of staff who helped towards the success of these functions.

The cricket club played 15 matches of which three were won, eleven lost and one drawn. The club again organised a dinner for members of the team and their friends. The hockey team played seven games of which two were won, two lost and three drawn. Both matches played against local clubs were won by the Station's lawn tennis team. Several inter-Station matches and tournaments were arranged during the season and an open mixed pairs tennis tournament was held concurrently with the garden fête. The table tennis club joined the Leamington and District League and played 16 matches. This club also arranged a tournament during the afternoon of the garden fête. Members of the stamp club attended two most interesting talks given by Mr. J. S. W. Cracknell when he visited the Station, and they also had the privilege of seeing his fine collection of Indian and French stamps in which he has specialised. Members are indebted to Mr. Cracknell for the time he has devoted to them, for his stimulating interest and advice, and for the catalogues and duplicates which he has kindly presented to the club.

The Station cricket and tennis teams were defeated at Bristol when they met the Long Ashton Research Station teams on 13th July. The opposing cricket team won by eight wickets and the tennis score was Long Ashton nine games, N.V.R.S. three. We are most grateful to the staff of Long Ashton for their kind hospitality and for a very enjoyable day's sport which was again the highlight of the season's fixtures.

RESEARCH

Plant Breeding

In work connected with the breeding of lettuce varieties resistant to mosaic virus disease, inoculation tests showed that the absence of symptoms of the disease on certain F_3 plants of summer lettuce was due to tolerance and not to immunity. No

symptomless F_3 plants bred true for this character but gave varying proportions of symptomless plants in their progenies.

Further progress has been made in breeding and selection work with the object of producing a non-bolting Detroit type of red beet having single-seeded fruit.

Following the promising preliminary results in the production of hybrid varieties of onions, inbreeding and selection has been carried out with Cambridge strains in order to provide suitable inbred lines as parents of hybrid varieties.

The production of selected inbred lines, and the making and testing of hybrids between inbred lines of Brussels sprouts has been continued as a necessary preliminary to the production of hybrid varieties. Hybrids between first generation inbreds showed some improvement on the parental varieties, but hybrids between first and second generation inbreds showed greater improvement in yield and quality. Male sterility, a characteristic of practical importance in the commercial production of hybrid seed, has now been discovered in three of the varieties being used for inbreeding.

Breeding work was begun with the object of producing a winter-hardy culinary pea of good quality, and breeding work was continued with early summer cauliflower and spring cabbage.

Studies of varieties of forcing radish in trials for two years have led to the conclusion that breeding and selection work by this Station is unnecessary since varieties of satisfactory performance and quality are available.

Supplies of nucleus stock seed of those Cambridge varieties which are on the market were again provided to the N.I.A.B. for stock seed production, the stock seed to be distributed to recognised seed growers for the production of commercial seed under the scheme described in the Annual Report for 1952.

Chemistry

During the first cycle of the three-year crop rotation of vegetables on the three long-term field experiments there was an accumulation of available phosphate and of available potash in the soil where FYM or high levels of fertilisers had been applied. FYM had also increased the total nitrogen in the soil. A striking effect of the application of FYM for three years, however, was shown on soil structure. The structure was such that, after a very wet winter in 1956-57, the soil was very wet but had no water lying on it, whereas the soil which had received no FYM was water-logged and had pools of water on it. The latter, as expected, had a bad effect on the crop and caused many plants to die. In general, the effects of the various treatments on crop production in 1957 were in agreement with those found in previous years, FYM again having produced the greatest effect on yield.

Chemical analysis of plant material from these experiments has been continued. Where applications of superphosphate had been omitted for four years the phosphate content of potato leaves decreased. Annual applications of superphosphate, however, maintained the phosphate content of the leaves but only slightly increased the yield of potatoes even although the phosphate status of the soil was low. Studies have also been in progress on the chemical changes which take place in the root of red beet when clamped and when flowering occurs.

Physiology

During the past year the Physiology Section was established again after having been in abeyance since 1952. Mr. Winter took over the responsibility of acting as Head of the Section in addition to being Head of the Irrigation Section. Dr. Bleasdale, who had been carrying out studies on the physiology of competition between weeds and vegetables in the Weeds Section, was transferred to the Physiology Section where he continued this work, and Mr. Austin was newly appointed to this Section.

Experiments showed that the minimum adverse effect of weeds on the yield of onions, red beet, and early carrots (under Dutch lights), was obtained when weeding was done once within a month of emergence of seedlings of the crop. It was also shown with peas that the effectiveness of weed control as reflected in crop yield was largely dependent on obtaining a reasonably good crop stand.

Growth studies were begun on carrots in one of the long-term field experiments of the Chemistry Section. The object of this work is to find out how each of various manurial treatments affects the growth of the crop and how this, in turn, affects the crop yield. An understanding of these effects may lead to the development of treatments giving improved productivity.

Investigations were started also to determine the best cultural treatments and the varieties most suited for the production of pickling onions in this country. Only three out of sixteen varieties tested in 1957 gave bulbs of the necessary shape, texture, colour, and pickling quality.

Studies are in progress on the effects of various treatments on the flowering of vegetables. Further knowledge on this subject should be of value for crop production, and for breeding and seed production work. Some advance has been made towards overcoming the problem of early flowering in the green variety of watercress. This problem has arisen as a result of the crop being raised from seed in order to obtain plants free from mosaic virus disease.

Irrigation

Early summer cauliflowers were grown in pots during the winter in Dutch light frames under moist conditions and under dry conditions. Those grown under dry conditions gave the greater number of 'buttons', and the number was further increased when the plants were subjected to dry conditions when transplanted in the field. It was found also that cold treatment during a certain stage in the development of the young plants increased the percentage of blind plants. Further studies on the irrigation of early summer cauliflower indicated that application of water could be delayed until 25 per cent of the available water in the root zone had been depleted, without adversely affecting the crop.

Experiments were begun with self-blanching celery. Effects of different soil moisture conditions at planting time and of different irrigation treatments during subsequent crop growth were compared. A study was also made of the effects of different watering and nutritional treatments.

Irrigation experiments, using oscillated spraylines on a rotation of vegetable crops, were continued in co-operation with the Experimental Horticulture Stations (E.H.S.) at Efford, Luddington, Rosewarne and Stockbridge House. Irrigation treatments were applied throughout the life of the crops and no protection from rain was given. Heavy watering treatment sometimes adversely affected the yield and possible factors contributing to this effect will be investigated.

Studies were continued on water loss from plants and soil. Evidence was obtained which showed that evapo-transpiration, under similar sets of conditions, differed with different kinds of crops.

An instrument for measuring soil moisture deficit was developed in 1955 and in subsequent tests has given satisfactory results. It consists of a combined rain gauge and evaporimeter, and should enable a grower to determine with ease the current moisture status of his soil and hence the maximum amount of irrigation water which he should apply.

Entomology

Further studies were made on species of beetles which are predators of the cabbage root fly in its immature stages and so help to control this pest. It has been found that different species of beetles were present at different stages of development of the crop and that this was connected with the natural preference or dislike of certain species for shade. It has been shown again that *low* rates of soil insecticide broadcast on the soil resulted in increased infestation of cabbage root fly on cabbage.

A treatment combining sodium molybdate and dieldrin has been developed for use with summer cauliflower for the control of the form of whiptail caused by molybdenum deficiency, and for the control of cabbage root fly.

Previous findings that low rates of aldrin or of dieldrin broadcast and incorporated in the top four inches of the soil give a lasting and highly effective control of carrot

fly on early maincrop and late carrots without causing taint or marked loss of flavour, have been confirmed. On medium sandy loam at Wellesbourne, one application of aldrin has now given complete control for three years.

Field experiments were again carried out testing dieldrin for the control of carrot fly and its larvae on parsnips. Dieldrin as a seed dressing, or sprayed on the soil before the end of July gave good control of the larvae. A higher degree of control was achieved, however, when either of these treatments was followed by a spray before mid-August. Spacing experiments showed that the percentage of roots attacked and the severity of the attack of the larvae was less on closely spaced plants than on widely spaced plants.

Although the attack of the root aphid on summer lettuce was light in 1957 it was possible to show that a seed dressing of 50 per cent endrin dust, which gave good control of a heavy infestation during 1955, could be improved upon if it were followed by a 0.2 per cent endrin band spray applied soon after singling the plants. Endrin-dressed lettuce seed when stored was found to have its viability impaired.

Pathology

In consequence of the previous promising results, zinc frit was tested for the control of crook root disease of watercress in commercial beds in 1956-57 both experimentally and by growers. The experiments showed that the treatment reduced the amount of infection from 95 to less than 5 per cent and the yields were more than doubled. Most growers also obtained satisfactory results. Laboratory studies elucidated the manner in which the zinc frit controlled the disease.

It has already been shown that seed treatment with the antibiotic streptomycin almost completely eliminated the bacteria causing silvering disease of red beet. Streptomycin is not available for use by seed growers but trials have now shown that several proprietary mercurial dusts used as seed treatments give a substantial measure of control which is less, however, than that obtained with streptomycin.

Further tests were made of various compounds, used as sprays, for their effectiveness as eradicants of, and/or protectants against *Didymella* stem rot disease of outdoor tomatoes. Maneb, a dithiocarbamate compound, gave a satisfactory result both as a protectant and as an eradicant. Captan proved to be an effective protectant. Infected seed again failed to give diseased plants. A strain of *Lycopersicum hirsutum*, var. *glabratum* has been found to be highly resistant to stem and root infection by *Didymella* and is being used as a parent in breeding for resistance in tomatoes.

It has now been established that the occurrence of the fungus *Itersonilia* on cankered parsnip is widespread in England and Wales. This fungus has been shown to produce lesions identical in appearance with those on naturally cankered roots. A species of the fungus *Phoma* has also been found on cankered parsnips. It was shown to be highly pathogenic to parsnips and produced lesions very similar to those caused by *Itersonilia*. Strains of parsnips have been selected which show reduced susceptibility to canker

Further tests of fungicides have confirmed the value of thiram sprays for the control of *Botrytis* disease of winter lettuce grown in frames or transplanted from frames in spring.

Tests of hybrid lettuce material have indicated that certain apparently healthy plants were symptomless carriers of mosaic virus disease.

Experiments have shown that diseased lettuce plants found in two parts of England during 1957 were suffering from Big Vein disease. Studies of the cause and of means of controlling the disease are in progress.

A trial carried out at Luddington E.H.S. in 1957 showed that high dosages of aldrin applied to the soil caused a reduction in club root disease and a corresponding increase in yields of summer cabbage.

Weed Investigations

It was reported last year that one year of vegetable cropping on very weedy corn land reduced the population of weed seeds in the soil to about half of what it was.

The second year of vegetable cropping resulted in a further decrease to approximately one-fifth of the original number. There were indications, however, that with certain cultivations the seed population of annual meadow grass (*Poa annua*) was beginning to increase.

Some promising results have been obtained with dinoseb (amine) used as a residual pre-emergence herbicide with broad beans, runner beans and dwarf French beans, and as a post-emergence herbicide with spring-sown field beans.

Additional trials with monuron have confirmed earlier results showing that it is an effective residual herbicide for annual weeds in established asparagus beds and does not adversely affect either the yield or flavour of the crop. Initial trials with another residual herbicide, simazin (2-chloro-4, 6-bis (ethylamino)-s-triazine), have given promising results.

CIPC (isopropyl N-(3-chlorophenyl) carbamate) has been tested further for the control of chickweed (*Stellaria media*) in transplanted spring cabbage, and of chickweed and annual meadow grass in autumn-sown salad onions. Encouraging results were obtained from tests with sodium monochloroacetate as a post-emergence herbicide for the control of broad-leaved weeds in young cabbage.

Statistics

The Statistics Section has continued to give advice and assistance to the research staff, to the N.A.A.S. Experimental Horticulture Stations and to other bodies. Requests by the research staff for such assistance have increased both in number and variety, and some have led to special studies being made by the Section.

Further work has been done with a view to improving, from both cultural and statistical aspects, the efficiency in technique for certain field experiments with vegetables. Some progress has been made with the fitting of curves to plant-growth data, and with the problem of discovering suitable scales for use when the environment in which the plants are growing is variable. With red beet, chitting of the seed and intensive weeding each increased the marketable yield and jointly reduced the percentage standard error.

A method of sampling plants in experiments on canning or quick-freezing peas, in order to determine the optimum harvesting date, which is a critical one, was tried but appeared to be unsatisfactory.

The Director has again served on the Advisory Committees of the N.A.A.S. Experimental Horticulture Stations, and acted as Chairman of the Vegetable Working Party which co-ordinates the experimental work on vegetables at these Stations. The close relationships and co-operation between these Stations and the N.V.R.S. have been maintained and we are appreciative of their having carried out field experiments in extension of those done at Wellesbourne. Mr. Cooke served on the Bulbs and Flowers Working Party ; Mr. Nelder on the Protected Cropping and Glasshouse Working Parties ; and Mr. Winter served on the Protected Cropping Working Party.

In seed maintenance and multiplication work and in trials of varieties, there was again full co-operation between the National Institute of Agricultural Botany and this Station, and the Director continued to serve on the Vegetable Trials Advisory Committee of the N.I.A.B.

Mr. Wright served on the Advisory Committee and the Joint Panel of the Crop Protection Products Approval Scheme of the Ministry of Agriculture, Fisheries and Food. He also served on the Taint Committee of the Agricultural Improvement Council. Mr. Roberts served on the Recommendations Committee of the British Weed Control Council.

Visitors

Approximately 700 visitors attended the Station's second Open Day held on 17th September 1957. Exhibits illustrated the work of the research sections and tours of the field experimental areas were arranged. 554 other visitors came to the Station during the year, including the following from overseas :—

Australia :	Mr. B. S. Janes, I.C.I., Melbourne.
	Mr. B. D. Robinson, Biological Research Station, Victoria.
	Mr. R. F. Doepel, North Freemantle.
Canada :	Mr. J. D. Galbraith, British Columbia.
France :	M. Jacques Delmas, Centre de Recherches Agronomiq, Bordeaux.
	M. Villeneuve, Paris.
Holland :	Ir. P. L. A. Couwenberg, Wychen.
	Ir. J. A. Huyskes, Wageningen.
	Ir. J. M. Jacobs, Naaldwyk.
	Ir. J. R. Jensma, Naaldwyk.
	Ir. W. van Soest, Naaldwyk.
	Ir. F. J. Noordenbos, Doornspijk.
	Ir. E. C. Prillevitz, Wageningen.
	Ir. K. Verkerk, Wageningen.
Iraq :	Professor N. Polunin, College of Arts and Science, Baghdad.
Israel :	Miss Hadasa Avigdori, Ministry of Agriculture, Tel Aviv.
Japan :	Professor Shizuo Kato, Tokyo.
New Zealand :	Mr. J. Glazebrook, Canterbury Agricultural College, Christchurch.
	Mr. R. A. Harrison, D.S.I.R., Auckland.
	Mr. K. J. McNaught, Rukuhia Soil Research Station, Hamilton.
Pakistan :	Mr. A. G. Mian, Colombo Plan Student.
South Africa :	Mr. J. van der Harjt, C.S.I.R.O.
	Mr. S. K. Winstanley, A.E. and C.I., Johannesburg.
	Mr. C. H. Pearson, S.A. Sugar Experiment Station, Edgecombe, Natal.
S. Rhodesia :	Mr. N. S. Benyislai.
Turkey :	Mr. Gunor Karel, Institute of Plant Protection, Ankara.
Uganda :	Mr. J. F. Archibald, Coffee Research Unit, Department of Agriculture.
U.S.A. :	Mr. E. Johnson, Campbell Soup Company, Camden, N.J.
	Professor L. K. Mann, University of California.
	Mr. M. W. Thomas, Stanford Research Institute, California.
	Dr. S. G. Younkin, Campbell Soup Company, Camden, N.J.
West Africa :	Mr. H. D. Tindall, Department of Agriculture, Freetown.
Yugoslavia :	Messrs. Korega, Markovic, Sioga, and Vety.
	Mr. H. Pasic, Hydrometeorological Institute, Sarajevo.
	Dr. E. Polak, Zagreb University.

The following parties visited the Station :

1956	
15th October... ...	Members of Rosewarne E.H.S. Advisory Committee and Vegetable Advisory Panel.
1957	
6th February ...	Staff and pupils from Stratford-upon-Avon Technical School.
12th June	Party of Wiltshire market growers.
24th June	Members of the Retail Fruit Trade Federation.
8th July	Staff and students from the School of Agriculture, Sutton Bonington.
22nd July	Staff and students from the University of Reading.
25th and 26th July ...	N.A.A.S. Horticultural Advisory Officers.
31st July	Members of the Gardeners' Club, Grassland Research Institute.
21st August	Staff and students from the University of Birmingham.
18th September ...	N.A.A.S. County Agricultural Officers.
19th September ...	Members of the staff of the Grassland Research Institute.
24th September ...	Members of the Seed Trade Association.

Acknowledgments

Special thanks are given to members of the staff who have carried out duties in addition to their normal work. Miss Baggs, Dr. Haworth, Mr. Nelder and Mr. Roberts, as members of the Library Committee, continued to assist in library matters, and Dr. Haigh, Dr. Keyworth, Mr. Norwood, Mr. Winter and Mr. Wright again served on the Glasshouse Committee. Miss Beardall, Miss Smith, Miss Warr, Mr. Bartlett (Treasurer), Dr. Johnson (Chairman) and Dr. Salter (Secretary) formed the Canteen Committee.

Grateful acknowledgment is also made to other members of the staff who helped in various ways, and to all the staff and employees for the loyal manner in which they carried out their work during the year.

Thanks are due to the Executive Committee and the Sub-Committees, and particularly to the Chairman of the Governing Body and the Chairmen of the Committees for the valuable assistance they have given. We are very sorry to have lost the services of two members of the Governing Body who have resigned and we thank them for the great help they have given ; Dr. H. V. Taylor, who was Chairman of the Organising Committee prior to the establishment of the Society, then Chairman of the Executive Committee, and subsequently Chairman of the Governing Body ; and Professor R. H. Stoughton who served on the Executive Committee and the Staff and Research Sub-Committee. Thanks are also due to Mr. E. R. Hoare for the assistance he gave as a co-opted member of the Farm Management Sub-Committee.

We are grateful to all those friends of the Station, particularly growers and commercial firms, who have kindly given books, seeds, plants and other material, and who have helped in so many ways.

J. PHILP,

26th *February* 1958.

FARM

By T. J. NORWOOD

Wellesbourne

Spring operations were delayed owing to the land being wet and the sowing season was rather prolonged. However, the weather that hindered the arable cultivations was beneficial to the grass, and cutting for silage making began on 1st May. Before the end of that month about 150 tons of young grass had been ensiled. In the hot, dry June, about 55 tons of hay was made in most favourable conditions. In general, growing conditions for vegetables were good. Dry winds in April and May, and high temperatures in June, made maximum demands on our irrigation facilities but from July onwards our greatest difficult was in keeping weed growth under control. Root crops benefited greatly from the summer rains and yields of carrots and onions were the best we have had at the Station. By the early use of systemic insecticides the aphis problem was never allowed to develop ; the brassicae were treated as a matter of routine against root fly attack, and carrot fly was also kept under control. Potato blight threatened to be severe but burning off the tops in September enabled a clean crop to be harvested and no undue rotting occurred in the stored potatoes.

Lack of winter frosts and the very wet conditions in spring made preparation of seed beds difficult. Spring-sown cereals suffered most and were further checked by drought during June. They gave only moderate yields but autumn-sown wheat over-wintered well and gave well above average yields.

During the winter cattle were fed in well strawed yards ; those not sold for beef by April went on to pasture and were graded as they reached the desired standard. Altogether 67 bullocks were sold as beef during the year. During the same period 35 litters of pigs were born and 333 pigs were registered on reaching eight weeks old. Most of these were sold for bacon but the best gilts were retained for breeding. About 600 tons of farmyard manure was produced for use in the production of vegetables for experimental purposes.

A loft was installed in one of the stores buildings for the accommodation of grain.

Paglesham

At Paglesham the general trend of crop yields closely resembled that of Wellesbourne. Moderate yields were obtained from the spring-sown cereals but the winter wheat gave good yields. Young leys, sown under spring wheat, became well established and began the winter in a healthy state of growth. Potato yields were also satisfactory. Brussels sprouts and onions were grown for seed and good crops of both were harvested.

A new seed drying shed was built and proved to be very effective for drying-off newly harvested seed crops, particularly onions, for it is often difficult to get the seed heads dry enough in the open without losing a large proportion of the seed. This new shed is undoubtedly a valuable acquisition and will be of great service in years to come.

In preparation for the grazing of the new leys, a post and wire fence has been erected along the boundaries of O.S. 126, and water has been piped to drinking troughs; the field will be divided by temporary wire fences into suitable paddocks as occasion demands.

The stock yard was divided into two sections by the erection of a central feeding passage with hay racks and troughs. This work was carried out by the farm staff. Thirty cattle were over-wintered in yards and subsequently graded for beef. A further 24 young cattle were bought in mid-summer for grazing the pastures already established. During the year, 70 pigs were reared and fed to bacon weights. A good supply of farmyard manure was produced for vegetable cropping.

PLANT BREEDING REPORT

By J. C. HAIGH

BREEDING PROJECTS

Lettuce (L. E. Watts and R. A. T. George)

The absence of symptoms of mosaic in plants in the 1956 trial (4) was shown, by back-inoculation to a susceptible variety, to be due to tolerance and not to immunity. In 1957, an F_4 generation was grown from selfed seed taken from symptomless plants of the F_3 generation, selected not only from the progenies which had shown no mosaic symptoms, but also from progenies showing varying degrees of infection. 71 F_4 progenies were grown in a layout similar to that previously used, in which rows of test plants alternated with rows of artificially-inoculated plants of a susceptible variety. Records were taken, late in the season (when the lowest degree of infection can be detected on the flowering bracts), of the numbers of infected plants and the degree of infection of each, ranging from 0 (no symptoms) to 3 (heavily-infected). A summary of these records is given in the table below.

F_3 generation (1956)			F_4 generation (1957)				
Progeny	% infected plants	No. of plants selected	No. of plants grown	Percentage infection in progenies			Mean symptom grading
				lowest	highest	mean	
55132	0	8	465	55	67	57	1-2
55158	0	7	371	46	79	58	2
55465	5	7	397	64	87	80	2-3
55912	7	6	416	80	100	91	2-3
55198	13	13	637	65	100	93	2-3
55131	17	3	212	59	79	69	2-3
55153	23	1	71	77	77	77	2-3
55141	25	3	200	70	88	80	3
55147	25	2	106	77	77	77	2-3
55150	51	6	405	64	89	73	2-3
55137	63	1	14	100	100	100	2
55718	65	8	538	94	100	99	3
55139	78	4	294	97	100	99	3

Two F_3 parents failed to set seed.

Symptoms of mosaic appeared in 1957 on F_4 plants derived by self-fertilisation from symptomless F_3 progenies. There was a general tendency for degrees of symptom expression in F_4 progenies to increase with the increase of symptom expression in the F_3 progenies containing the selected parents. Symptomless F_4 plants were selected and selfed to produce material for further study.

Progenies of plants of the variety Borough Wonder grown from irradiated seed (4)

were exposed in 1957 to infection by lettuce mosaic and all succumbed ; no recessive mutation to resistance had resulted, therefore, from the irradiation. However, of the 557 plants grown in 1956 from the treated seed, only 12 set selfed seed under the very poor weather conditions of August and September, and the seed gave only 900 plants, so that the chances of getting a particular mutation were negligible. A much larger population will be grown from treated seed in 1958.

An F_2 generation was grown from hybrids between Cheshunt Early Giant and each of three summer varieties (1) and was exposed to attack by lettuce mosaic. Selected infected plants were selfed and the progenies of these plants will be raised in 1958 under aphid-proof conditions in order to detect any lines in which mosaic has been transmitted through the seed. Any lines showing no seedling infection will be kept for further work.

Red beet (H. Holland and G. J. Frost)

Some progress has been made in the selection of a non-bolting strain of Detroit (1). From an early sown, light-treated population of 2,000 plants grown in 1955, four plants which had not bolted were allowed to inter-cross in 1956 and the seed was collected separately from each plant. Progenies from these four plants, together with one from a commercial strain of Detroit, were raised from an early sowing and were planted in the field in the form of a 5×5 latin square with 100 plants per plot. At the time when the plants would have been lifted for the early market (75 per cent with root diameter at least two inches), two of the progenies and the control had 60-80 per cent bolters whilst the other two progenies had 5-20 per cent. By the end of August, however, only 14 roots which had not bolted remained from the original 2,500, and were distributed as follows : control plots 5, early-bolting progenies 4, and late-bolting progenies 5. The last group will be kept for further selection.

Brussels sprouts (A. G. Johnson and G. J. Faulkner)

Test crosses between selected inbred lines of Brussels sprouts were grown in 1957, in order to collect data on combining ability and on hybrid vigour. The first trial was of hybrids between selected S_1 plants of the variety Cambridge No. 3. It showed that the vigour lost on selfing was restored or even exceeded, but the differences in combining ability between individuals were small. This result suggests that the S_1 inbred lines were genetically similar, either because of the initial uniformity of the parent stock or because inbreeding had not gone far enough. That the latter is the more likely explanation is indicated by the considerable differences shown between S_2 progenies from the same selected S_1 plants, indicating that considerable segregation was still occurring.

The second trial was of hybrids between the same selected S_1 plants of Cambridge No. 3 and selected S_2 plants of Cambridge Special. Vigour was equal to that of non-inbred material and most of the hybrids had the dark leaf and sprout colour, and the high sprout quality, of the Cambridge Special parent. The best family of these hybrids gave a yield better by 66 per cent than that of the higher-yielding parent variety, Cambridge No. 3, and 76 per cent better than that of the mean yield of the two parental varieties.

Male sterility was discovered in 1957 in S_1 material of Cambridge No. 1 and has now been found in each of the three varieties that have been inbred. The use of a male sterile parent will greatly facilitate the production of hybrid seed and the character is being introduced where necessary into good inbred lines. Male sterility was also found (one plant in 5,000) in a nucleus stock seed population of Cambridge No. 1 and there is little doubt that it can be found in many varieties if trouble is taken to look for it. The advantages of finding it in the variety being bred, instead of having to introduce it from some quite different source, are so great as to make a careful search for it worthwhile.

Figures have been given (2) to illustrate the increased yield to be obtained as a result of making progeny tests on plants selected by eye as seed bearers and keeping

for seeding only those which gave the best progeny rows. The method involved selfing a part of each plant to provide seed for the progeny test, maintaining the parent plants vegetatively until the result of the test was known, and taking a second crop of seed by mass pollination of the best of the parents.

A simple variant of this method is to mass pollinate all the selected parents but to collect the seed from each separately. A sample of seed from each parent is used to do the progeny test ; when the result of the test is known the remaining seed of the plants which gave the best progeny rows is bulked and used to grow the next generation. The seed produced by the poorer parents (as determined by the progeny test) is discarded. This method has given good results but is probably less efficient than the one previously described for two reasons. First, seed is produced by mass pollination and, therefore, the poorer parents will have contributed pollen even though their own seed may be discarded, thus adversely affecting the yield. Secondly, since the seed has been produced by mass pollination, differences between progenies will be less, and may be more difficult to assess. On the other hand, neither selfing nor vegetative reproduction of parent plants is involved and the technique is thereby much simplified.

Onions (H. Holland and G. J. Frost)

The hybrids between American male sterile varieties and Cambridge lines, of which the field performance was reported in 1956 (1), were grown on to flowering in 1957. Those which had line K1 as male parent were all male sterile, indicating that the genotype of K1 was *ms ms* (3) and since cytoplasmic male sterility has not been found in this line, the cytoplasmic factor must be *N*. This combination (*N ms ms*) is that required in the male parent if male sterile hybrids are to be produced. Another Cambridge line (No. 28) produced some male fertile progenies, and some which were male fertile and male sterile in equal proportions, indicating that the genotypes were *Ms Ms* and *Ms ms*. Since these two genotypes have been found, the third (*ms ms*) can be obtained and as no male sterility has been found in No. 28, the cytoplasmic factor must again be *N*. The other Cambridge lines (Nos. 10 and 33) gave progenies containing both male fertile and male sterile plants, so that the genotype *ms ms* should again be obtainable.

In the course of this work on the production of hybrid onions, the Cambridge lines are being inbred in order to isolate suitable uniform material for eventual use as parents. The heterogeneity of the lines was demonstrated by the segregation of types differing in maturity, in bulb shape, size and colour, and the extent of such segregation was enhanced under the poor growing conditions of 1957, in contrast to the good growing conditions of 1955 which tended to minimise differences.

Forcing radish (L. E. Watts and R. A. T. George)

An account of two years' work with commercial varieties of forcing radish will be found later in this report. It is concluded from this work that a breeding programme is not urgently needed, since commercial varieties of satisfactory quality are already available.

Peas (H. Holland and G. J. Frost)

An attempt is being made to produce a winter-hardy culinary pea of good quality. Seed of an Austrian winter maple pea, kindly supplied by the Plant Breeding Institute, Cambridge, and of 12 varieties of round and wrinkled types of culinary peas, were sown in the open in October 1955. The severe weather of February 1956, when 24° of frost were recorded on one night and the mean temperature for the month was 31°F., killed off all the commercial types but none of the maples. Crosses were made in 1956 between these maple plants and culinary varieties, and by sowing plants in the glasshouse, F_2 generations, first backcross generations from the F_1 to the culinary types, and selfed progenies of these backcrosses had all been produced by the autumn of 1957. Samples of all these hybrid types will be sown in the field in November 1957 in order to allow natural selection for winter hardiness to take place.

SEED PRODUCTION

Nucleus stock seed was produced of the following varieties :—

Brussels sprouts	Cambridge Special	at Wellesbourne.
Onion	Cambridge No. 10	
Onion	Cambridge No. 10 at Paglesham.	

Plants were grown and selected for the production in 1958 of nucleus stock seed of the following varieties :—

Brussels sprouts	Cambridge Special	at Wellesbourne.
Brussels sprouts	Cambridge No. 1	
Onion	Cambridge No. 10	
Brussels sprouts	Cambridge No. 5	at Paglesham.
Onion	Cambridge No. 10	

WORK AT OUTSIDE CENTRES

Facilities were again provided at Luddington Experimental Horticulture Station (E.H.S.) for observing the incidence of clubroot on some cabbage varieties, and at the John Innes Horticultural Institution for work on the deterioration of Brussels sprouts varieties. Selections of Roscoff broccoli were made at Rosewarne, and Efford E.H.S. It is a pleasure to record our appreciation of the ready co-operation given by the Directors and staffs of these Stations.

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CLASSIFICATION AND PERFORMANCE OF VARIETIES OF RADISH

By L. E. WATTS and R. A. T. GEORGE

INTRODUCTION

Classifications of lettuce (1), spring cabbage (2) and red beet (3), have been made at Wellesbourne as preliminaries to a breeding programme. These classifications are made necessary by the multiplicity of names given to an apparently limited number of types. A similar situation in radish (*Raphanus sativus* L.) led to a survey being made at Wellesbourne in order to establish such a classification.

114 varieties were grown, consisting of 59 from foreign sources and 55 British. Most of the varieties were differently named, but a few varieties having the same name, although from different sources, were included in order to ensure that varieties with similar or identical names were also similar in type. As in the red beet classification, mentioned previously, this procedure was of value as some varieties with identical names were found to be dissimilar in type, e.g., Scarlet Gem (Clibran) belongs to Class B, while Scarlet Gem (Little and Ballantyne) belongs to Class A.

Previous classifications of radish have been made by Banga (4), and Banga and Bennekom (5), but these deal only with varieties produced by Dutch seeds firms, and no performance data are given.

The normal method of seed production in radish is by cross-pollination of large numbers of selected parent plants, and varieties consequently cannot be classified as synonymous. The grouping together of varieties is, therefore, on the basis of maximum similarity to one another. Self-pollination is uncommon because of the presence of a sporophytically-controlled self-incompatibility mechanism (6). This control may be so rigid that incompatible pollen grains either do not germinate, or the pollen tubes become twisted and eventually abort. The heterogeneity produced by cross-pollination is more marked in some varieties than others, being exhibited mainly in root shapes and, to a lesser extent, in root colour. Fig. 1 provides an indication of the variation in root width and length within groups in relation to their mean.

Characters used in classification

(a) *Root shape and colour*

Varieties can be divided into three main colour classes (red, white, or red and white) combined with three main root shapes (globe, intermediate or long), but only seven of the nine possible combinations have been found in commercial varieties, the two missing classes being white intermediate, and red and white long radish. The red and white class can be sub-divided by variations in the proportion of the two colours, and all classes can be sub-divided further by differences in shape between varieties.

(b) *Leaf size and colour*

These characters are fairly uniform within any variety and are therefore important when classification by root shapes is difficult. Five sizes of leaves were recorded ; small (2-3¼ inches), small/medium (3½-5 inches), medium (5¼-7 inches), medium/large (7¼-10 inches), and large (10¼-13 inches).

(c) *Root weights*

Although weight of root is of little importance in the marketing of radish, the roots of each variety were weighed when each root was considered to have reached market maturity so that a check could be made on the visual classification. The mean weight of 48 roots of each variety is given in the performance tables, the weights for the long white and long red classes, however, being based on the mean weight of 24 roots.

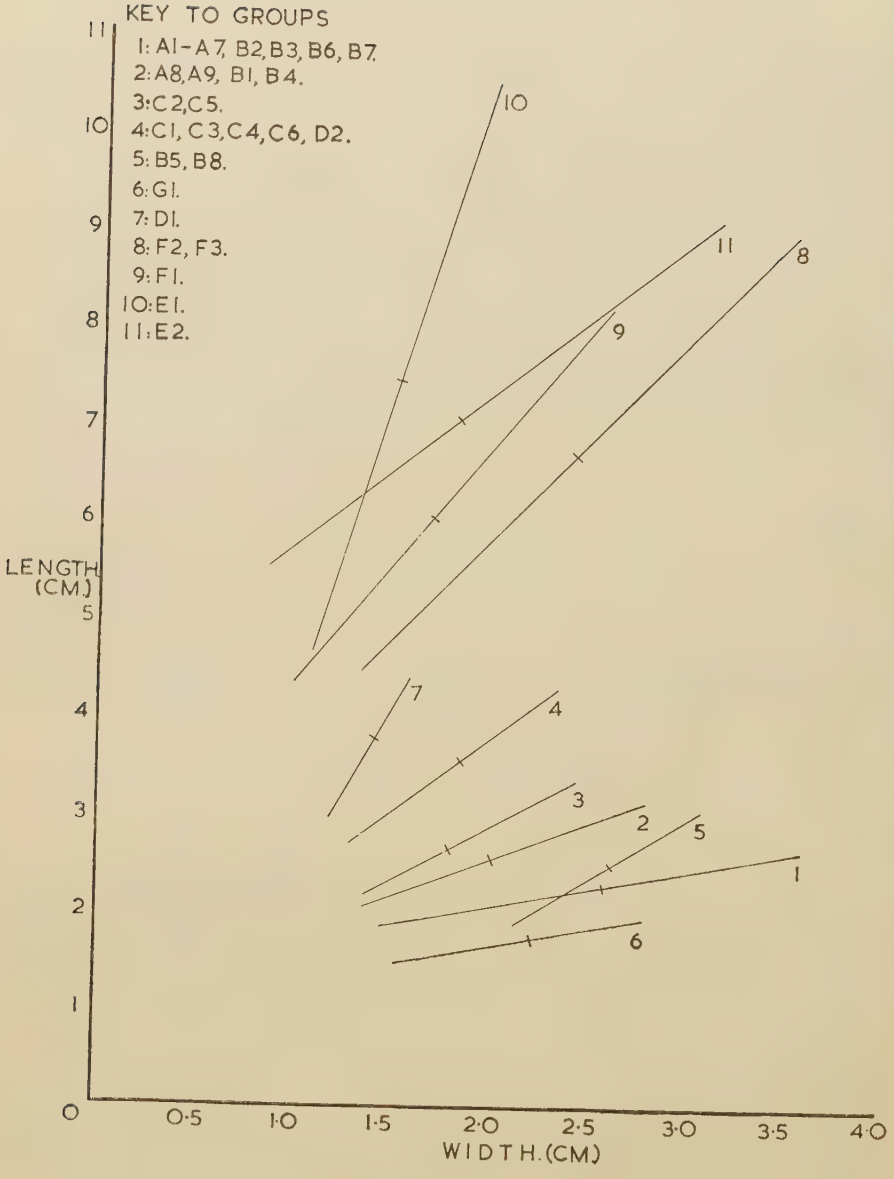

Fig. 1. Range of length/width ratios within and between groups of Radish varieties.

Mean dates of harvest are given as the number of days after the harvest date of Bunyard's Scarlet Forcing (Group A8).

(d) *Leaf number and form*

The number of completely unfolded leaves at harvest is quite constant within a variety. The form of the leaves differs according to their order of initiation. The first one or two are usually entire, but those following are pinnate. The ratio of entire to pinnate does not differ greatly between varieties, however, and only the total number of leaves is included in the classification.

(e) *Seed weight*

It has been stated elsewhere (7) that seed sizes differ between radish varieties, and the weights of 500 seeds of each variety have been determined. These weights have been converted to give the approximate number of seeds per ounce and are given alongside the appropriate variety in the performance tables. Although considerable variation in seed weights occurs between varieties within the same group, the weights for any particular variety appear to be relatively constant from year to year.

Experimental procedure

The varieties were sown under Dutch lights on 12th February 1954, and on 28th February 1956. Each variety was spot sown at 3 in. by 3 in., the seedlings being thinned at a very early stage to give 24 plants per plot in each of three randomised blocks. Three varieties and their guard rows were grown under each Dutch light. Plants were harvested at the stage of market maturity. The yield data given later are based on the yield from two replications in 1956, the third replication being allowed to remain so that varietal differences in bolting characteristics could be studied.

Classification

Seven main classes are listed—red globe, red and white globe, white globe, red intermediate, red and white intermediate, long red, and long white, and these are divided into 31 groups. Varietal names, with their respective groupings are indexed and included as an appendix.

Class A. Red globe

An early maturing class with red roots. The majority of varieties possess dull red roots, but those indicated by an asterisk are scarlet.

Group A1

Small leaves. Mean root proportions length/width 0.94 to 1.07.

Variety	*Supplier*	*Variety*	*Supplier*
*Dunns Early Brilliance	Dunn	Saxa	C.E.F. Ottawa (Canada)
Fogwills Forcing	Fogwill	Saxa	Hurst
*Kelway's Fireball	Kelway	Saxa Short Top	Daehnfeldt (Denmark)
Radis de tous les mois. Boule de feu	E. Müller (Switzerland)	Saxa Vinter	Ohlsens Enke (Denmark)
Red Turnip Short Top, Forcing	Watkins & Simpson	O.E./50	
		Scarlet Star	Cullen
		*Turnip, Express, Earliest Scarlet Short Top	Sharpe

Group A2

Small leaves. Root colour is a very dull red, some roots being almost puce. Mean root proportions length/width 0.93 to 1.00.

Variety	*Supplier*
Ronde Rode Broei	Sluis en Groot (Netherlands)
Dobies' Scarlet Star	Dobie (*Chester*)

Group A3

Small/medium leaves. Root colour as Group A1. Mean root proportions 0.92 to 1.17.

Variety	*Supplier*	*Variety*	*Supplier*
Cavalier	Asgrow (U.S.A.)	441 Julbloss W:S	Weibull (Sweden)
Comet	C.E.F. Ottawa (Canada)	Ne Plus Ultra	Hurst
Crimson Giant	Alex Dickson	Radis de tous les mois de Dreienbrunnen	E. Müller (Switzerland)
Dazzler Forcing	Chase		
E.W.K.'s Earliest of All	E. W. King	Saxa Gef./49	Gehlins (Sweden)
Extra Early Scarlet Round	Carter	Saxa OJO/49	Otto J. Olson (Sweden)
		Short Top Forcing	Tozer
Fest und Früh	Dippe (Germany)	Toogood's Giant Crimson Forcing	Toogood
Harrisons' Bonnie	Harrison (*Leicester*)		
Harrisons' Cherry	Harrison (*Leicester*)	Webbs' Ruby Gem	Webb

Group A4

Small/medium leaves. Root colour mainly dull red. Separated from other groups by the heterogeneity of the roots, which include a small proportion of angular and inverted beet shapes. Mean root proportions indeterminate.

Variety	*Supplier*	*Variety*	*Supplier*
Amager round forcing	Chr. Olsen (Denmark)	Crimson King	J. K. King

Group A5

Medium/large leaves. Similar variety to those of the previous group, but less heterogeneity in root shape. Mean root proportions length/width 0.94.

Variety	*Supplier*
Würzburgh	Ohlsens Enke (Denmark)

Group A6

Small leaves. Roots of similar colour to previous group but differing in shape which is of a flattened globe type. Mean root proportions length/width 0.85 to 0.91. The last variety is extremely uniform, but its leaves are almost too small for bunching purposes.

Variety	*Supplier*	*Variety*	*Supplier*
Cherry Belle	University of Manitoba (Canada)	Glowing Ball	E. W. King
		Toogood's Express	Toogood
Elsoms Select Saxa	Elsoms (*Spalding*)	Ronde rode Kortloof	Beusekom (Netherlands)

Group A7

Small/medium leaves. This group is similar in root form to the previous one. The first named variety is more uniform in root shape than the remainder, while the last two varieties tend to split at the base of the root if allowed to become over-mature. Mean root proportions length/width 0.78 to 0.91.

Variety	*Supplier*	*Variety*	*Supplier*
Saxa forcing	Chr. Olsen (Denmark)	Sutton's Red Forcing	Sutton
Non plus ultra	Daehnfeldt (Denmark)	Clibrans' Extra Early Forcing	Clibrans
Radis de tous les mois non plus ultra	E. Müller (Switzerland)	Dreienbrunnen	Ohlsens Enke (Denmark)

Group A8

Small/medium leaves. Roots of a dull red colour, globe to long. Mean root proportions length/width 1.22 to 1.28.

Variety	*Supplier*
Bunyard's Scarlet Forcing	Bunyard
L. & B.'s Scarlet Gem (Turnip-shaped)	Little and Ballantyne
Round Red Winter	Ohlsens Enke (Denmark)

Group A9

Small/medium leaves. The placing of the undermentioned variety into a separate group was because of the marked heterogeneity of its roots, most of which tended to be of intermediate shape. Mean root proportions length/width 1.39.

Variety	*Supplier*
Saxa Vinter OJO/54	Otto J. Olson (Sweden)

TABLE 1

Group	Variety	Mean weight in oz. 48 roots 1956	Mean harvest date	Mean leaf number	Mean root proportions Length/width	Approx. No. of seeds/oz.
A1	Dunns Early Brilliance	14.50	+6	4.5	0.95	3,100
	Fogwill's Forcing	8.50	+8	4.0	0.95	3,500
	Kelway's Fireball	9.50	+6	4.0	1.03	4,500
	Radis de tous les mois. Boule de feu	13.00	+3	4.1	1.01	3,100
	Red Turnip, Short Top, Forcing...	10.75	+2	4.0	1.06	3,000
	Saxa (C.E.F. Ottawa)	10.25	+4	4.5	0.97	2,800
	Saxa (Hurst)	10.50	+5	4.3	0.99	—
	Saxa Short Top	10.50	+1	4.6	0.95	3,500
	Saxa Vinter O.E./50	12.00	+5	4.1	0.97	3,800
	Scarlet Star	11.25	+5	3.9	1.07	3,200
	Turnip, Express Earliest Scarlet Short Top	9.75	+6	3.9	0.94	4,000
A2	Ronde Rode Broei	9.75	+3	3.8	0.93	4,500
	Dobies Scarlet Star	11.00	+4	4.3	1.00	3,100
A3	Cavalier	12.00	+4	4.9	0.98	2,700
	Comet	10.75	+3	4.9	1.00	2,800
	Crimson Giant	13.50	+3	4.6	1.16	2,200
	Dazzler Forcing	13.75	+8	4.4	1.06	3,500
	E.W.K.'s Earliest of All	13.75	+6	4.4	1.13	3,500
	Extra Early Scarlet Round ...	13.00	+6	5.0	0.93	3,200
	Fest und Früh	18.25	+4	4.6	0.95	3,100
	Harrisons' Bonnie	12.50	+5	4.1	1.09	4,000
	Harrisons' Cherry	18.00	+6	5.3	1.17	4,100
	441 Julbloss W:S	13.50	+3	3.9	1.04	2,700
	Ne Plus Ultra	11.50	+1	4.1	0.90	3,000
	Radis de tous les mois de Dreienbrunnen	12.75	+6	4.0	0.96	—
	Saxa Gef./49	11.20	+5	3.9	0.92	—
	Saxa OJO/49	13.75	+4	3.6	0.92	2,600
	Short Top Forcing	12.50	+4	4.2	1.04	3,100
	Toogood's Giant Crimson Forcing	12.00	+4	4.8	1.08	2,900
	Webbs' Ruby Gem	10.00	+3	4.3	1.07	2,600
A4	Amager round forcing	15.35	+6	4.6	1.01	2,800
	Crimson King	12.39	+10	4.4	1.09	—
A5	Würzburgh	18.50	+3	4.7	0.94	2,700
A6	Cherry Belle	11.25	+5	4.3	0.83	3,000
	Elsoms Select Saxa	11.50	+4	4.1	0.85	6,700
	Glowing Ball	12.25	+3	4.4	0.87	3,300
	Ronde Rode Kortloof	12.25	+5	4.2	0.86	4,400
	Toogood's Express	10.25	+3	3.8	0.91	3,700
A7	Clibrans' Extra Early Forcing ...	11.00	+1	4.3	0.90	2,800
	Dreienbrunnen	12.25	+4	4.5	0.79	3,000
	Non plus ultra	14.75	+6	4.5	0.86	3,500
	Radis de tous les mois non plus ultra	13.50	+5	4.5	0.90	3,400
	Saxa forcing	14.25	+5	5.0	0.85	2,900
	Sutton's Red Forcing	13.00	+2	4.1	0.78	3,000
A8	Bunyard's Scarlet Forcing ...	13.20	0	4.5	1.23	3,300
	L. & B.'s Scarlet Gem (Turnip-shaped)	11.35	+14	4.6	1.28	3,100
	Round Red Winter	11.75	+2	3.9	1.22	2,800
A9	Saxa Vinter OJO/54	14.50	+5	3.8	1.39	3,000

Mean weight : s.e. for difference between two means of varieties = ±1.068 oz.

Class B. Red and white globe

An early maturing class with roots similar in shape to Class A. Prior to harvest this class is almost indistinguishable from the previous one but the below-ground portions possess varying proportions of whiteness. Separation into groups is made on leaf size, root shape and root colour. A very popular bunching type.

Group B1

Small leaves. Globe to long of a dull red colour with white bases extending to approximately one-eighth of the root. Good uniformity in maturity and root shape. Mean root proportions length/width 1.11 to 1.40.

Variety	*Supplier*	*Variety*	*Supplier*
Klenod E/50	Ohlsens Enke (Denmark)	Rubin Vinter OJO/50	Otto. J. Olson (Sweden)
		Rubin Vinter OJO/54	Otto. J. Olson (Sweden)

Group B2

Small leaves. Uniformity good in all characters. Very similar to the above group but roots are oblate with one-eighth white base. Mean root proportions length/width 0.85.

Variety	*Supplier*
A Forcer ronde rose à bout blanc	Vilmorin (France)

Group B3

Small/medium leaves. Early and evenly maturing. Globular roots with one-third white at base. Mean root proportions length/width 0.92 to 1.07.

Variety	*Supplier*	*Variety*	*Supplier*
Gaudry	Daehnfeldt (Denmark)	Gefion nr. 203	Ohlsens Enke (Denmark)

Group B4

Small/medium leaves which are coarsely serrated, otherwise similar to Group B3 but root shape is slightly more heterogeneous. Mean root proportions length/width 1.25.

Variety	*Supplier*
Early Amager Round	Ohlsens Enke (Denmark)

Group B5

Medium leaves. Very similar to Group B3 but differs from it in leaf length and in the amount of white (one-eighth) at the base. Mean root proportions length/width 0.96.

Variety	*Supplier*
Rund Amager Driv.	Daehnfeldt (Denmark)

Group B6

Medium leaves. Oblate roots with one-third white base. Uniform and evenly maturing varieties, but the last named tends to split slightly at the base if not marketed at early maturity. Mean root proportions length/width 0.80 to 0.94.

Variety	*Supplier*
Brilliant	Fogwill
Gaudrey, or Forcing Sparkler	Harrison (*Leicester*)
Gaudry W:S/49	Weibull (Sweden)

Group B7

Medium leaves. These varieties are attractive, very uniform and early maturing. Globular roots with one-third white base. Mean root proportions. Length/width 0.92 to 1.05.

Variety	*Supplier*	*Variety*	*Supplier*
A Forcer Gaudry	Vilmorin (France)	Johnson's Perfection	Johnson
Barr's Scarlet Perfection	Wallace and Barr	Kelway's Red Cap	Kelway
		Radis de tous les mois. Gaudry	E. Müller (Switzerland)
Clibran's Scarlet Gem	Clibran		
Early White-tipped Scarlet	Woodhead	Ryders' Delicacy	Ryder
		Webbs' Crimson Ball	Webb
Fogwills Victoria	Fogwill		
Gefion	Ohlsens Enke (Denmark)		

Group B8

Medium/large leaves. An attractive variety with larger leaves than the average type. Early maturing. Oblate roots with one-third white base. Mean root proportions length/width 0.87.

Variety	*Supplier*
Sparkler	C.E.F. Ottawa (Canada)

TABLE II

Group	Variety	Mean weight in oz. 48 roots 1956	Mean harvest date	Mean leaf number	Mean root proportions Length/width	Approx. No. of seeds/oz.
B1	Klenod E/50	10.50	+5	4.3	1.22	2,900
	Rubin Vinter OJO/50	12.20	+1	4.1	1.11	2,100
	Rubin Vinter OJO/54	7.75	+1	3.1	1.40	2,200
B2	A Forcer ronde rose à bout blanc	9.50	+1	3.7	0.85	2,600
B3	Gaudry	9.00	+2	3.7	0.92	3,400
	Gefion nr. 203	13.50	+2	4.3	1.07	2,600
B4	Early Amager Round	9.00	+2	3.6	1.25	2,700
B5	Rund Amager Driv.	14.35	+10	4.7	0.96	—
B6	Brilliant	12.25	+2	5.2	0.80	2,900
	Gaudrey, or Forcing Sparkler ...	13.50	−7	4.1	0.91	—
	Gaudry W:S/49	11.25	+2	4.0	0.94	3,200
B7	A Forcer Gaudry	11.00	+2	4.0	0.99	3,500
	Barr's Scarlet Perfection	9.35	+11	5.0	1.01	3,300
	Clibrans' Scarlet Gem	11.75	+6	4.9	0.93	3,800
	Early White-tipped Scarlet ...	17.40	—	5.4	1.05	4,000
	Fogwill's Victoria	12.25	+3	4.4	0.95	3,800
	Gefion	12.75	+2	4.0	1.01	3,000
	Johnson's Perfection	8.00	+2	4.4	0.93	3,100
	Kelway's Red Cap	13.55	+10	4.6	1.03	4,600
	Radis de tous les mois. Gaudry ...	12.25	−2	4.1	0.99	2,800
	Ryders' Delicacy	12.25	+5	4.5	0.98	3,300
	Webbs' Crimson Ball	18.45	+7	5.1	1.00	—
B8	Sparkler	19.25	+9	5.4	0.87	2,900

Mean weight : s.e. for difference between two means of varieties = ±1.790 oz.

Class C. Red and white intermediate

A very popular type which matures very slightly later than the two preceding classes. Root shapes are intermediate in form, but vary considerably in width, the narrower types being preferred.

Group C1

Small/medium leaves. The last-named variety possessed rather smaller leaves of which 30 per cent were rather glossy. Fairly narrow dull red roots with a white tip Mean root proportions length/width 1.95 to 2.51.

Variety	*Supplier*
Amager medellång W:S/49 Original (Weibulls Brilliant)	Weibull (Sweden)
Amager Oval OJO/49	Otto J. Olson (Sweden)
Delicatess Elit 1954	Gehlin (Sweden)
Delikat OJO/52	Otto J. Olson (Sweden)
French Breakfast	Dunn
French Breakfast F1454 47085	D. E. S. Saanichton, Ottawa (Canada)
French Breakfast forcing	Chr. Olsen (Denmark)
Harrisons' Tip-Top	Harrison (*Leicester*)
Pernot OJO/52	Otto J. Olson (Sweden)
Speed's Scarlet Knight	Speed
Amager Oval Vinter OJO/54	Otto J. Olson (Sweden)

Group C2

Small/medium leaves. This group is rather uneven in its maturity but root shapes are quite uniform. Fat/intermediate root with one-third white base. Mean root proportions length/width 1.63 to 1.80.

Variety	*Supplier*	*Variety*	*Supplier*
Carters Sixteen Days	Carters	Webbs' Improved French Breakfast	Webb

Group C3

Medium leaves, otherwise similar to the above group but more even in maturity. Mean root proportions length/width 1.77.

Variety	*Supplier*
Early Amager, Oval Shape	Ohlsens Enke (Denmark)

Group C4

Small/medium leaves. Root shape as above but with white on the root tip only. This variety has a wider base than apex and is rather wrinkled. Mean root proportions length/width 1.88.

Variety	*Supplier*
à forcer demi-long écarlate à bout blanc	Vilmorin (France)

Group C5

Small/medium leaves. Fat intermediate root with white tip. Mean root proportions length/width 1.41 to 1.59.

Variety	*Supplier*	*Variety*	*Supplier*
French Breakfast	Bees	French Breakfast	D.E.S. Saanichton, Ottawa (Canada)

Group C6

Small/medium leaves. Long/intermediate root with white tip. Mean root proportions length/width 2.40 to 2.45.

Variety	*Supplier*	*Variety*	*Supplier*
de 18 Jours	Vilmorin (France)	Half Long Red, White Tip	Ohlsens Enke (Denmark)
D'Orleans	Vilmorin (France)		

TABLE III

Group	Variety	Mean weight in oz. 48 roots 1956	Mean harvest date	Mean leaf number	Mean root proportions Length/width	Approx. No. of seeds/oz.
C1	Amager medellång W:S/49 Original (Weibulls Brilliant) ...	10.40	+2	3.6	2.03	2,400
	Amager Oval OJO/49	12.75	+2	3.1	1.81	2,500
	Delicatess Elit 1954	11.00	+2	3.1	2.51	3,000
	Delikat OJO/52	9.25	+2	3.1	2.51	3,300
	French Breakfast (Dunn) ...	10.25	+7	3.1	2.15	3,100
	French Breakfast F1454 47085 ...	10.70	+7	4.3	1.95	—
	French Breakfast forcing ...	8.25	+2	2.8	2.33	2,900
	Harrisons' Tip-Top	9.00	+2	2.9	2.12	3,300
	Pernot OJO/52	10.25	+2	3.1	2.16	4,100
	Speed's Scarlet Knight	11.75	+3	3.3	2.32	2,700
	Amager Oval Vinter OJO/54 ...	9.50	+2	2.3	2.18	2,500
C2	Carters' Sixteen Days	10.75	+9	3.5	1.63	2,900
	Webbs' Improved French Breakfast	10.80	+10	3.7	1.80	5,700
C3	Early Amager, Oval Shape ...	14.00	+4	4.0	1.77	2,400
C4	à forcer demi-long écarlate à bout blanc	9.25	+2	4.0	1.88	2,500
C5	French Breakfast (Bees)	9.50	+2	3.6	1.59	3,500
	French Breakfast (D.E.S. Saanichton)	6.75	+7	4.0	1.41	3,100
C6	de 18 Jours	11.00	+2	3.6	2.40	3,100
	D'Orleans	8.85	+2	3.4	2.44	3,000
	Half Long Red White Tip ...	10.70	+6	3.0	2.45	—

Mean weight : s.e. for difference between two means of varieties = ±1.222 oz.

Class D. Red intermediate

This class is rather uncommon and has only two representatives. Root shapes are similar to those of Class C, but the root is completely red.

Group D1

Small/medium leaves. This variety is very uniform and matures earlier than the majority of varieties within Class C. Long/intermediate root. Mean root proportions length/width 2.65.

Variety	*Supplier*
Amager Medellång Gef./49	Gehlin (Sweden)

Group D2

Small/medium leaves. An attractive variety, differing from the above only in root proportions. Fat/intermediate, mean root proportions length/width 1.71.

Variety	*Supplier*
Svendborg Torve	Daehnfeldt (Denmark)

TABLE IV

Group	Variety	Mean weight in oz. 48 roots 1956	Mean harvest date	Mean leaf number	Mean root proportions Length/ width	Approx. No. of seeds/ oz.
D1	Amager Medellång Gef./49 ...	10.00	+1	2.6	2.65	2,800
D2	Svendborg Torve	10.75	+1	3.1	1.71	2,800

Class E. Long red

This class consists of varieties with long red tapering roots and although they can be grown with success under Dutch lights when sown in January or February, they mature more slowly than the preceding classes. Maturity is quite uniform within and between varieties.

Group E1

Medium/large leaves. Roots red. Mean root proportions length/width 4.76.

Variety	*Supplier*
Early Scarlet Frame	Fidler

Group E2

Large leaves, but otherwise similar to the previous group. The roots of the last-named variety in this group are pale red, however. Mean root proportions length/width 3.12 to 5.59.

Variety	*Supplier*
Barr's Early Red	Wallace and Barr
Chartier	Asgrow (U.S.A.)
Daniels' Best of All	Daniels
Fidler's Perfection	Fidler
Fidler's Scarlet Model	Fidler
Finney's Glowing Scarlet	Finney
Laxton's Early Wonder	Laxton
Long Bright Scarlet	Alexander and Brown
Radis rosé de Pâques	Vilmorin (France)
Webb's Improved Early Frame	Webb
Woods Early Frame	Unwin
Radis de tous les mois glaçon long rouge	E. Müller (Switzerland)

TABLE V

Group	Variety	Mean weight in oz. 24 roots 1956	Mean harvest date	Mean leaf number	Mean root proportions Length/width	Approx. No. of seeds/oz.
E1	Early Scarlet Frame	12.94	+16	3.3	4.75	—
E2	Barr's Early Red	10.50	+3	4.3	5.09	2,300
	Chartier	14.82	+12	6.0	5.29	2,000
	Daniels' Best of All	6.25	+10	4.3	4.02	3,100
	Fidler's Perfection	12.00	+5	5.8	5.59	2,000
	Fidler's Scarlet Model	8.25	+11	4.2	3.89	1,900
	Finney's Glowing Scarlet ...	Insufficient plants	—	—	—	1,800
	Laxton's Early Wonder	9.90	+11	4.6	5.42	2,300
	Long Bright Scarlet	13.00	+11	4.9	4.01	3,000
	Radis rosé de Pâques	24.50	+18	5.8	3.12	2,000
	Radis de tous les mois glaçon, long rouge	Insufficient plants	—	—	—	3,000
	Webbs' Improved Early Frame ...	do.	—	—	—	2,000
	Woods' Early Frame	do.	—	—	—	2,000

Class F. Long white

Similar in shape but slower to reach maturity than the previous class. The roots are completely white, with the exception of a small amount of green or puce upon the shoulders of some plants or varieties. This class is not very widely grown.

Group F1

Medium/large leaves. A good uniform variety. Roots have slightly green sloping shoulders. Mean root proportions length/width 3.84.

Variety	*Supplier*
Icicle (Short Top) F1666 48107	D.E.S. Saanichton, Ottawa (Canada)

Group F2

Large leaves. Roots of the same shape as the above group. Mean root proportions length/width 2.43 to 4.02.

Variety	*Supplier*	*Variety*	*Supplier*
Barr's Early White	Wallace and Barr	White Icicle	D. E. S. Saanichton, Ottawa (Canada)
Webb's Long White	Webb (*Stourbridge*)		
Rave à forcer blanche transparent	Vilmorin	White Strasburg	Ferry-Morse (U.S.A.)

Group F3

Large leaves. Roots with 'carrot type' shoulders. Mean root proportions length/width 2.20.

Variety	*Supplier*
Weisser Ostergruss	Dippe (Germany)

TABLE VI

Group	Variety	Mean weight in oz. 24 roots 1956	Mean harvest date	Mean leaf number	Mean root proportions Length/width	Approx. No. of seeds/oz.
F1	Icicle (Short Top) F1666 48107...	21.00	+4	4.3	3.84	3,500
F2	Barrs' Early White	18.75	+18	5.6	3.22	2,300
	Webbs' Long White	21.00	+14	5.7	4.02	2,800
	Rave à forcer blanche transparent	24.25	+12	4.3	3.43	2,600
	White Icicle	17.25	+5	3.8	3.23	2,600
	White Strasburg	17.00	+11	5.4	2.43	3,100
F3	Weisser Ostergruss	35.00	+20	5.9	2.20	3,200

Class G. White globe

This class is represented by only one variety, the root type being extremely uncommon.

Group G1

Small/medium leaves. Oblate root, pure white in colour. Mean root proportions length/width 0.80.

Variety	*Supplier*
White Globe	Alexander and Brown

TABLE VII

Group	Variety	Mean weight in oz. 48 roots 1956	Mean harvest date	Mean leaf number	Mean root proportions Length/width	Approx. No. of seeds/oz.
G1	White Globe	8.25	+2	4.3	0.80	3,300

DISCUSSION

The foregoing classification indicates that the most popular radish type (based on the numbers of varieties offered for sale) is the red globe with 48 varieties, while the red and white globes and intermediate are also well represented, with 23 and 20 varieties respectively. The globe types of radish become mature slightly earlier than the intermediate types, but the short growing period of these first three classes is obviously an important factor in their popularity.

With few exceptions the varieties within these classes possess small or small/medium leaves. For bunching purposes the latter are preferable, the former often being too short for secure tying when the roots are bunched in dozens. Leaf sizes are highly uniform within varieties but this uniformity is not so apparent in colour and shape of the roots. Special mention has been made in the classification of varieties showing exceptional uniformity or heterogeneity. Some roots exhibiting shapes or colour patterns which were not typical of the particular variety were selected for further observation. In order to determine whether the morphological differences were due to contamination during seeding, the selected plants were self-pollinated in the bud stage, and their progeny were grown to determine whether segregation of characters would occur.

The inheritance of root colour is determined by a pair of genes which, in association with a gene for the expression of colour, give a purple F_1 in a cross between red and white varieties (8). Root shape is also determined by a pair of genes, the F_1 of a cross between globe and long varieties being of an intermediate shape (9).

Two purple roots from a red globe and a long white variety respectively, produced selfed progenies which segregated for colour after self-pollination, while a root of intermediate shape from a red globe variety produced long and globe roots in its selfed progeny. The presence of these off-types indicated that a limited amount of cross-pollination occurred during the seeding of these varieties. It appears that heterogeneity within a variety may have resulted from inadequate roguing of seed parents, or insufficient isolation between radish crops grown for seed. The great majority of the varieties studied, however, showed a high degree of uniformity, and the small number of off-types which occurred were of only minor importance.

The radish varieties under review in this paper comprise a wide range of types and, apart from one or two poor samples, there appears to be very little need for improvement. One character in which improvement is necessary, however, is that of solidity of roots. The period over which any variety remains edible (i.e., non-pithy) is at present almost unknown, and it is hoped that experiments, now taking place at Wellesbourne, will indicate the possibility of producing roots which will remain in a marketable condition for a longer period.

SUMMARY

114 varieties of radish have been grown at the N.V.R.S. and have been divided into seven classes. Sub-division of these classes into 31 groups has been based upon distinctions between root and leaf shapes and sizes. Lists of varieties and details of performance are given.

Acknowledgment

We should like to thank Mr. J. A. Nelder for his advice on the statistical analyses, and Miss C. H. Beardall and Miss P. A. Dymond for their help with the recording.

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APPENDIX

INDEX OF CLASSIFICATION AND GROUPING OF RADISH VARIETIES

Variety	*Class (Initial) and Group (Numeral)*
A Forcer ronde rose à bout blanc	B.2
A Forcer Gaudry	B.7
á forcer demi-long écarlate à bout blanc	C.4
Amager Medellång Gef./49	D.1
Amager Medellång W:S/49 Original (Weibulls Brilliant)	C.1
Amager Oval OJO/49	C.1
Amager Oval Vinter OJO/54	C.1
Amager Round Forcing	A.4
Barr's Early Red	E.2
Barr's Scarlet Perfection	B.7
Barr's Early White	F.2
Brilliant	B.6
Bunyard's Scarlet Forcing	A.8
Carters Sixteen Days	C.2
Cavalier	A.3
Chartier	E.2
Cherry Belle	A.6

APPENDIX—*contd.*

INDEX OF CLASSIFICATION AND GROUPING OF RADISH VARIETIES

Variety	*Class (Initial) and Group (Numeral)*
Clibrans' Extra Early Forcing	A.7
Clibrans' Scarlet Gem	B.7
Crimson Giant	A.3
Crimson King	A.4
Comet	A.3
Daniels' Best of All	E.2
Dazzler Forcing	A.3
de 18 jours	C.6
Delicatess Elit 1954	C.1
Delikat OJO/52	C.1
Dobies' Scarlet Star	A.2
D'Orleans	C.6
Dreienbrunnen	A.7
Dunns Early Brilliance	A.1
Early Amager, Oval Shape	C.3
Early Amager Round	B.4
Early Scarlet Frame	E.1
Early White-tipped Scarlet	B.7
Elsoms Select Saxa	A.6
E.W.K.'s Earliest of All	A.3
Extra Early Scarlet Round	A.3
Fest und Früh	A.3
Fidler's Perfection	E.2
Fidler's Scarlet Model	E.2
Finney's Glowing Scarlet	E.2
Fogwills Forcing	A.1
Fogwills Victoria	B.7
French Breakfast (Dunn)	C.1
French Breakfast (Bees)	C.5
French Breakfast (D.E.S. Saanichton, Ottawa)	C.5
French Breakfast Forcing	C.1
French Breakfast F1454 47085	C.1
Gaudry	B.3
Gaudry W:S/49	B.6
Gaudrey, or Forcing Sparkler	B.6
Gefion	B.7
Gefion nr. 203	B.3
Glowing Ball	A.6
Half Long Red White Tip	C.6
Harrisons' Bonnie	A.3
Harrisons' Cherry	A.3
Harrisons' Tip-Top	C.1
Icicle (Short Top) F1666 48107	F.1
Johnson's Perfection	B.7
441 Julbloss W:S	A.3
Kelway's Fireball	A.1
Kelway's Red Cap	B.7
Klenod E/50	B.1
L. & B.'s Scarlet Gem (Turnip-shaped)	A.8
Laxton's Early Wonder	E.2
Long Bright Scarlet	E.2
Ne Plus Ultra	A.3
Non Plus Ultra	A.7
Pernot OJO/52	C.1
Radis de tous les mois. Boule de feu	A.1
Radis de tous les mois de Dreienbrunnen	A.3
Radis de tous les mois. Gaudry	B.7
Radis de tous les mois glaçon, long rouge	E.2
Radis de tous les mois non plus ultra	A.7
Radis rosé de Pâques	E.2
Rave à forcer blanche transparent	F.2
Red Turnip, Short Top, Forcing	A.1
Ronde Rode Broei	A.2
Ronde Rode Kortloof	A.6
Round Red Winter	A.8
Rubin Vinter OJO/50	B.1
Rubin Vinter OJO/54	B.1
Rund Amager Driv.	B.5
Ryders' Delicacy	B.7
Saxa (Hurst)	A.1
Saxa (C.E.F. Ottawa)	A.1
Saxa Forcing	A.7
Saxa Gef./49	A.3
Saxa OJO/49	A.3
Saxa Short Top	A.1
Saxa Vinter O.E./50	A.1
Saxa Vinter OJO/54	A.9
Scarlet Star	A.1
Short Top Forcing	A.3
Sparkler	B.8
Speed's Scarlet Knight	C.1
Sutton's Red Forcing	A.7
Svendborg Torve	D.2
Toogood's Express	A.6
Toogood's Giant Crimson Forcing	A.3
Turnip, Express, Earliest Scarlet Short Top	A.1
Webbs' Crimson Ball	B.7
Webbs' Improved Early Frame	E.2
Webbs' Improved French Breakfast	C.2
Webbs' Long White	F.2
Webbs' Ruby Gem	A.3
Weisser Ostergruss	F.3
White Globe	G.1
White Icicle	F.2
White Strasburg	F.2
Woods Early Frame	E.2
Würzburgh	A.5

ADDENDUM

It has recently been brought to the notice of the authors that a white intermediate (or olive shaped) radish is in existence although this class was not listed in any of the catalogues studied. A further variety, Scarlet Globe, was also not listed in the catalogues but it is understood to be a variety adapted to early sowing as it produces foliage more suitable for an early bunching crop than the red turnip short top Saxa types. The only class not now represented is the red and white long radish.

CHEMISTRY REPORT

By F. HAWORTH

FIELD EXPERIMENTS

Soil samples taken from all plots of the three long-term field experiments (1, 2) during the winter of 1956-57, at the end of the first three-year cycle of cropping, have been analysed. The results show that during the period 1953-56 there was a steady build-up of available phosphate (Morgan's solution) and available potash on those plots which had received applications of FYM or the higher levels of fertilisers. The total nitrogen in the soils increased where FYM had been applied but the level remained fairly constant where fertilisers alone had been used.

The *p*H of the soils from the experimental area had remained fairly constant ; there was a slight fall on plots which had received inorganic fertilisers alone and a slight rise on plots which, in addition, had received applications of FYM. After consideration of the *p*H status of the soils over the whole of the experimental area, ground limestone was applied at the rate of 15 cwt. per acre over the whole of the nitrogen (N), and the NPK-FYM factorial experiments. This rate was calculated to give a resultant *p*H of about 6.5.

The pattern of yields described for 1956 (2) was maintained during the cropping season of 1956-57. Red beet and carrots, however, showed small but significant responses in yield attributable to applications of phosphatic fertilisers.

Cultivation experiment

The wet and relatively mild autumn and winter of 1956-57 encouraged the growth of weeds, especially of annual meadow grass (*Poa annua*) in the leek and spring cabbage crops, and also prevented weeding operations from being carried out effectively. Annual meadow grass was much more prevalent on the shallowly cultivated plots than on the deeply cultivated ones and was most abundant on the rotavated plots.

During February and March 1957 parts of Phase II of this experiment were under water for several weeks and the spring cabbage crop was adversely affected. This flooding did not appear to be connected with the cultivation treatments but occurred in slight general depressions over the experimental area. However, most of the plants recovered and a reasonably good yield of spring cabbage was harvested and, as in previous years, the deeply cultivated plots outyielded the shallowly cultivated plots.

The wet conditions in late March made the preparation of the seed bed for the pea crop very difficult and as a result of an indifferent seed bed and intense drying conditions soon after the crop had been drilled, the stand of peas was thin and gappy. While the stand of plants was better on plots which had received FYM, there were many irregularities and it would be unwise to attach too much importance to this result. The leek and Brussels sprout crops in this experiment had not been harvested at the time of writing.

Nitrogen experiment

Differences in soil structure between plots which had received FYM annually for three years and plots which had received fertilisers only for this period, was strikingly demonstrated in March 1957 at the end of an almost continuously wet winter. The plots which had received no FYM since the beginning of the experiment were completely waterlogged and had pools of water on the soil surface whereas the plots to which FYM had been applied, although very wet, were not waterlogged and had no free water standing on them. Many spring cabbage plants died on the waterlogged plots but casualties were few on plots which were not waterlogged. A summary of the yields of spring cabbage obtained from this experiment is given in Table I.

TABLE 1

Effect of nitrogen source and method of application on the yield of spring cabbage, 1956-57

	Applications × cwt./acre	Crates (40 lb.) per acre	
		With FYM	No FYM
Nitrochalk	1×6	550	230
	4×¾	420	150
	4×1½	600	300
	4×2¼	780	400
Hoof and horn meal	1×8	330	120

The effect of FYM on yield was most marked and it will be seen also that even at the highest level of nitrogen application (139 lb. N. per acre) there was no evidence of a falling off in yield response.

NPK-FYM factorial experiment

In March 1957 the differences in soil conditions between plots which had received annual applications of FYM and plots which had received inorganic fertilisers alone for the past three years were similar to those described for the corresponding series of plots of the N experiment. The spring cabbage plants grew rapidly in April and on those plots where there had been few deaths during the winter, a satisfactory crop was harvested on 6th-7th May. The effect of the rate of application of nitrogenous fertilisers on the total yield of marketable produce (hearted + greens) and on the yield of hearted cabbage expressed as a percentage of the total marketable yield, is shown in Table II.

TABLE II

Effect of nitrogen level on hearting of spring cabbage, 1956-57

Nitrochalk cwt./acre	With FYM		No FYM	
	Total crates/acre	% hearted	Total crates/acre	% hearted
3	450	45	160	12
6	610	59	290	36
9	750	68	400	42

Both the total yield of marketable produce and the percentage of hearted cabbage were increased at the higher nitrogen levels. The yield obtained at a given nitrogen level agreed closely with the yield obtained from the same level of nitrogen in the N experiment, and the yield response showed no falling off at the highest level of nitrogen application. The early potato sets were planted into a poor seed bed and the stand of plants obtained was uneven. The crop was not irrigated during the dry period in May and June 1957, and many plants died on those plots which had not received FYM as part of their manurial treatment. The response to potassic fertiliser applications was smaller in the presence of FYM than in its absence and increased with increasing level of nitrogen application.

The red beet and carrot crops could not be sown until 14th June but despite this late sowing date excellent crops were obtained. Red beet gave increases in yield attributable to the three major nutrients, nitrogen, phosphorus and potassium as well as to FYM. Both FYM and potassic fertiliser applications increased the yield of carrots ; nitrogenous fertilisers increased the yield in the presence of FYM but depressed the yield when FYM was not applied.

Leaf samples were collected at frequent intervals during the growing season from the early potato, red beet and carrot crops. Analysis of the potato leaves showed that the application of FYM or of potassic fertilisers to the plots increased their content of potassium. The amount of phosphorus in leaves from plots which had received no phosphate fertilisers for four years had fallen to about 40 per cent of that found in leaves from plots which had received annual applications of 1 cwt. per acre of ordinary superphosphate. This large difference in leaf phosphorus status was not reflected in differences in the yield of potatoes, for the yields from the two series of plots were almost identical.

Self-blanching celery

Further investigations were made into the possible causes of internal stem breakdown of self-blanching celery (2). A wide range of manurial treatments was used and heavy yields were obtained. The amount of internal stem breakdown over the whole experiment, however, was too small to allow valid conclusions to be drawn on the effects of the manurial treatments on this condition. It is probable that factors other than nutrition are involved and it is proposed to investigate some of these factors during 1958.

Runner beans

The response of runner beans, variety Kelvedon Wonder, to soil physical conditions and nutrient supply was studied in a randomised block experiment with four replicates of the following treatments :—control, FYM, peat, fertiliser, peat with fertiliser, and FYM with fertiliser. The fertiliser application contained all the major nutrients ; minor nutrients were applied as sprays to the plants during the growing season. The FYM was applied at the rate of 30 tons per acre and the peat application contained an amount of organic matter equivalent to that contained in the FYM. The experiment was watered as thought necessary.

The differences in total growth and in yield of beans between the various manurial treatments was most striking. The differences in growth were so great that plots which had received FYM could be recognised at a distance of a hundred yards or more. The yields of beans obtained are given in Table III.

TABLE III

Yield of runner beans. Kgs. per 4×20 *sq. yard*

Treatment	No fertiliser	Fertiliser
Control	24.2	84.9
Peat	38.6	109.8
FYM	189.7	200.4

In addition to the large differences in yield produced by the various treatments, differences in the distribution of the crop over the picking period were found. The yield from the FYM plots was heavy in the early part of the picking season and decreased as the season progressed, whereas the yield from plots which had received

fertiliser applications started at a low level in the early part of the season and gradually increased. Chemical analysis showed that the mineral composition of plants from plots which had not received FYM was similar to what would be expected in plants grown under acid soil conditions. On the other hand, plants from plots which had received FYM had a mineral composition similar to that expected in plants grown under neutral soil conditions. In fact, however, the *p*H of the soil was at a value of about 6.2 at both the beginning and the end of the experiment. Very few nodules were found on roots examined in July and August and in October nodules were found on only five plants out of 240.

ORGANIC CONSTITUENTS OF RED BEET (S. P. Spragg and J. Clare Hughes)

During 1955 and 1956 red beet roots, taken from plots of the NPK-FYM factorial experiment (1) were analysed for sugars, and nitrogenous constituents and the results indicated that differences attributable to seasonal variations were much greater than differences brought about by the experimental treatments. In view of this and the known effects of low temperatures on the incidence of flowering of red beet in its first year of growth (3), a study of the effects of storage and of low temperatures on the organic constituents of the root has been started.

Red beet roots, variety Detroit Globe, harvested in October 1956 were placed in clamps for the winter. In March 1957 the roots were planted in the field and were allowed to flower. Samples of roots taken immediately after clamping and at intervals during growth were analysed. The results showed that during clamping a partial inversion of the sucrose had taken place leading to the accumulation of glucose and fructose in the stored roots. The total soluble nitrogenous constituents of the roots remained relatively constant during clamping but changes had occurred in the relative proportions of the free amino acids.

After the roots were planted, the amount of sugar and total soluble nitrogen decreased temporarily during leaf formation. Following the formation and growth of the first leaves, both the nitrogenous and carbohydrate constituents of the root increased prior to the beginning of the extension of the flowering stalk. The amount of sugars and soluble nitrogenous constituents in the root then decreased, the latter more rapidly than the former. Visual examination suggested that during flowering the red pigment of the roots was markedly altered and this was confirmed by a study of the electrophoretic behaviour of the extracted pigment. Similar investigations were carried out on plants grown from seed sown in March 1957, and which flowered in July 1957. In general, the changes which took place in the soluble nitrogenous constituents during flowering were similar to those found in plants flowering in their second year of growth.

The studies of chemical changes during growth in the field were supplemented by laboratory experiments on the effects of different storage temperatures on the root constituents. Storage of roots for up to two weeks at 0°C. - 5°C. resulted in little change in the amount of soluble sugars. It may be relevant to this result that at no stage of growth so far examined could starch be detected in red beet roots. Marked changes were observed in the organic and inorganic phosphate fractions of the root during cold treatment.

GERMINATION OF SEEDS (S. P. Spragg and J. Clare Hughes)

An examination of the biochemical factors affecting the germination of seeds was begun. The pea seed was chosen as experimental material since a considerable amount of information was already available concerning the biochemistry of this seed. In the early stages of germination of the pea seed, marked quantitative changes in the glutathione take place. Our experiments have shown that the germination of the seed is connected with these changes, and that the subsequent growth of the seedling is also partially dependent on the availability of glutathione. The use of chemicals which are selective in action demonstrated that the rate of growth of the seedling can be moderated by reactions involving glutathione. Maleic hydrazide was included among

the chemicals used. This compound stops cell division, and a study of its effect on the biochemistry of the pea seedling has shown that changes in glutathione are connected with normal mitotic division of plant cells.

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PLANT PHYSIOLOGY REPORT

By E. J. WINTER

The Physiology Section was formed again during the past year. Work on intra- and inter-specific competition between weeds and vegetables was taken over from the Weeds Section. Research was also begun with the object of ascertaining the physiological basis for certain results obtained in the Chemistry Section's long-term manurial and cultivation experiments. In addition, various methods were tested, including the use of gibberellic acid, for controlling the flowering of vegetables. In collaboration with the Statistics Section, an investigation was started on the cause of the differences in germination, and subsequent performance, of different lots of onion seed of the same variety, these lots of seed having been produced at different places.

COMPETITION STUDIES (J. K. A. Bleasdale)

The difficulties encountered in the statistical analysis of previous experiments designed to determine the quantitative relationship between the degree of weed infestation and crop yield (2), have made it necessary to modify the approach to this problem. A large scale experiment on competition between bunching carrots and chickweed, carried out with the co-operation of Mr. J. A. Nelder, yielded data that is amenable to statistical analysis. In particular the relative growth rates of populations are being studied in detail. The selection of a suitable 'time scale' has been shown to be of great importance and the relative merits of days, day degrees, sun hours, incoming radiation, net radiation (calculated), calculated evaporation, and actual evaporation from an open water surface, are at present being investigated.

The experiment on the weeding of main crop onions (2) has been repeated. The weed stand encountered in 1957 was considerably less than in 1956. Nevertheless, a similar trend in the results demonstrated that weeding within a month of emergence was necessary to obtain the highest yield. Similar results were obtained in an experiment on red beet.

The experiment on the time of weed removal from early carrots grown under Dutch lights (1) has been repeated with modifications. On plots that were weeded once, those weeded 28 days after emergence gave as high a yield of marketable roots as plots kept weed free. This was in agreement with the results obtained in 1955 (2). Postponement of weeding till later than 35 days after crop emergence reduced the final yield of marketable roots.

Field experiments on the effects of different amounts of weed on the yield of peas and carrots at different spacings have been carried out. The tentative practical conclusion from the experiment on peas is that the nearer the crop density approaches the optimum the greater the absolute benefit to be derived from weed control. Thus a weed control method that would not pay at low crop densities becomes profitable as the density is increased. In the carrot experiment one crop density of approximately 45 plants per square yard was achieved in 12 in. and 24 in. row spacings. Half of each plot was kept free of weeds whilst the other half was mechanically inter-row cultivated leaving a band of weeds in the row. The weed stand was very low and did not significantly affect crop yield. The 12 in. row spacing gave a 40 per cent higher yield of marketable roots than the 24 in. row spacing. As would be expected, inter-row cultivation left twice the number of weeds on the plots with 12 in. row spacing as compared with plots with 24 in. row spacing. At harvest, however, there was only half the weight of weed on the plots with 12 in. row spacing as compared with those having 24 in. row spacing. These results indicate that the spatial arrangement of a carrot crop can affect its yield and competitive ability.

GROWTH STUDIES (R. Austin)

Using material obtained from the Chemistry Section's NPK-FYM factorial experiment (3), the growth of a carrot crop (variety Clucas' New Model) was followed by means of fortnightly samplings from 16 plots, during the period June to October 1957. The plots chosen represented every combination of four factors at the lowest and highest levels used in the main experiment, namely : 15·5 and 46·5 lb. nitrogen per acre, 0 and 36 lb. phosphate (P_2O_5) per acre, 0 and 96 lb. potash (K_2O) per acre and 0 and 20 tons of farmyard manure per acre. Each sampling consisted of 10 plants taken at random from each plot, and the fresh and dry weights of leaves and of roots were recorded.

Growth curves were constructed by plotting fresh and dry weights against time and against accumulated water-loss from an open water surface (see Stanhill p.39). When drawn on a time scale the growth curves levelled off sharply at a point corresponding to the onset of autumn. When expressed on the accumulated water-loss scale, growth was approximately exponential.

The relationship between growth of tap root and leaves could be described by the allometric equation of the form $\log y = \log a + b. \log x$.

In all samplings the weight of leaves from plots which had received FYM exceeded that from plots which had not received FYM. For a given root weight, the corresponding weight of leaves was greater in the +FYM plots than in the —FYM plots, and it is suggested that the FYM increased yield of roots through its effect on the leaves.

Harvests of one-quarter of the area of each plot were carried out on 24th September and 4th November. At the first harvest it was found that the application of FYM was the only manurial treatment which had significantly increased root yield. At the second harvest, in addition to a significant increase resulting from application of FYM, an increase from potash also approached significance, while the interaction between the effects of potash and FYM was significant and negative. These findings were in keeping with the yield data obtained in the main experiment to date (4). Chemical analyses are in progress with a view to determining the relationship between manurial treatment and mineral composition of the root and leaf tissues and growth.

EXPERIMENTS ON GROWING ONIONS FOR PICKLING (R. Austin)

Experiments to compare the yield of pickling onions from 16 different varieties have been carried out at Wellesbourne, Efford E.H.S. and Stockbridge House E.H.S. Seed was sown in April at the rate of 30 lb. per acre in rows nine inches apart and the onions were harvested in early September. The Wellesbourne experiment received 10 cwt. per acre of inorganic fertiliser containing 5 per cent nitrogen, 12.5 per cent phosphate (P_2O_5) and 12.5 per cent potash (K_2O). The Efford experiment received 30 tons per acre of farmyard manure, and 9 cwt. per acre of fertiliser containing 9 per cent nitrogen, 9 per cent phosphate, 15 per cent potash, and aldrin soil insecticide. The yields from the Stockbridge House experiment were too low to be of interest and hence the data are not included here.

After harvest the bulbs were riddled into four size-grades : (a) less than 1 inch diameter, (b) 1 inch to $1\frac{1}{4}$ inches, (c) $1\frac{1}{4}$ inches to $1\frac{1}{2}$ inches, and (d) above $1\frac{1}{2}$ inches. The grades required by the pickling trade are No. 1, 1 inch to $1\frac{3}{8}$ inches, and No. 2, $1\frac{3}{8}$ inches to $1\frac{5}{8}$ inches. The yields of marketable picklers as assessed in these experiments (grades b and c), therefore, will be under-estimated. Samples of bulbs of grades b and c of each variety from each Station were judged by representatives of the pickling trade, by arrangement with the British Food Manufacturing Industries Research Association. Taking into consideration shape, texture and colour, only Cambridge No. 3, Giant Zittau and New Brown Pickling (Thoday's) were satisfactory, while Rijnsburger and Big Ben were just acceptable. The yields of these varieties are shown in Table I. After a pickling test, the varieties Giant Zittau, New Brown Pickling (Thoday's) and Rijnsburger were judged as having satisfactory pickling qualities.

TABLE I

Yield, in tons per acre, from varieties giving bulbs of suitable size, shape and texture for pickling.

VARIETY	WELLESBOURNE		EFFORD	
	Total yield	Marketable yield	Total yield	Marketable yield
Cambridge No. 3	19.5	11.3	20.9	8.8
Giant Zittau	19.1	12.0	20.9	10.0
New Brown Pickling (Thoday's) ..	16.7	9.3	19.8	7.7
Rijnsburger	16.7	10.7	19.9	7.8
Big Ben	17.7	9.9	19.2	8.1

A preliminary trial of various cultural conditions including sowing rate, row width, sowing date and fertiliser treatment has indicated that all these factors greatly affect the yield of onions marketable as picklers. These factors will be further investigated.

THE PROPAGATION OF WATERCRESS FROM SEED (J. K. A. Bleasdale)

The green and brown varieties of watercress both suffer from mosaic virus disease. Tomlinson (6) has shown that the mosaic virus of green watercress (*Nasturtium officinale*) is not seed transmitted and hence healthy plants can be raised from seed. Such a procedure cannot be adopted with brown watercress (*N. officinale* x *microphyllum*) since it is a sterile triploid. This discovery encouraged growers to replace brown with green watercress but in the process of meeting their requirement of seed it appears that there has been an unconscious selection of strains with undesirable early flowering characteristics.

During 1957 it was shown that *N. officinale* was a long-day plant and this knowledge made possible the selection, under glasshouse conditions, of late flowering strains which are at present being tested in a commercial cress bed.

The post harvest ripening and the germination requirements of green watercress seed are also being studied. Contrary to the findings of Howard and Lyon (5) it was found that the seed as shed by the plant would not germinate if held with adequate moisture at 20°C. The seed as shed was a pale straw colour. During storage under conditions of high relative humidity the seed colour changed to dark brown and a period of dry storage was found to be necessary before this dark brown seed would germinate at 20°C.

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IRRIGATION REPORT

By E. J. WINTER

In our irrigation experiments, the emphasis is shifting from treatments applied throughout the life of the plants to treatments applied at certain stages of growth. The determination of moisture-sensitive and drought-sensitive growth stages has an obvious practical bearing.

In general, abundant water supply has been found to increase the quantity of foliage produced by most vegetable plants, and to increase the yield of saleable material to a smaller though usually worthwhile extent. Frequent irrigation retarded maturity of certain crops and has improved the quality of some but impaired that of others.

Irrigating spinach, runner beans and marrows by sprinkling the water over the foliage caused no yield differences as compared with applying the same quantity of water directly to the soil without wetting the leaves.

In continuation of the development of the irrigation gauge (7), six of these instruments, operating continuously at the weather station throughout the summer, gave readings in agreement with one another and with the measured water loss from a crop, to within half-an-inch of the soil moisture deficit. Professor J. P. Hudson kindly set up two of the evaporation units of these gauges in his lysimeter tomato house at Sutton Bonington. Here also, from June to September, the readings agreed very closely with the measured water loss from the crop.

IRRIGATION OF A ROTATION OF CROPS

(E. J. Winter and F. Lucy C. Blackwall)

Table I shows some of the results obtained in the long-term experiments on the irrigation of various crops at the N.A.A.S. E.H.S. (8). In the right-hand column, results obtained on smaller plots at Wellesbourne are shown for comparison.

TABLE I

Some effects on yield of vegetables of irrigation (maximum permitted deficit of ½ inch or 1 inch) compared with no irrigation; treatments applied throughout the life of each crop. The effects shown were statistically significant.

	Experimental Horticulture Stations (N.A.A.S.)					Wellesbourne : typical results from small plots obtained in different years
	Luddington		Stockbridge House		Efford	
	1956	1957	1956	1957	1957	
Early summer cauliflower ...	increase	increase	no effect	no effect	increase	increase
Early lettuce ...	no effect	no effect	no effect	crop failed	decrease	no effect
Summer lettuce	no effect	decrease	crop failed	no effect	crop failed	increase
Autumn lettuce	—	increase	—	—	—	no effect
Carrot	increase in leaves	decrease in roots ; increase in leaves	—	—	—	increase
Self-blanching celery ...	increase	increase	no effect	decrease	—	increase

Near to the time of sowing or planting each crop, the soil of all plots was restored, by irrigation, to field capacity. The following treatments were then given.

Treatment A No watering other than rainfall.

Treatment B Whenever the accumulated soil moisture deficit amounted to half-an-inch, the soil was restored, by irrigation, to field capacity.

Treatment C (In 1956, the conditions for applying water never arose (4) and the treatment was altered for the 1957 season). Whenever the accumulated soil moisture deficit amounted to one inch, the soil was restored, by irrigation, to field capacity.

It must be emphasised that treatment *B* intentionally involved heavier watering than would normally be carried out commercially; one of the objects of the experiments was to ascertain which crops could withstand comparatively heavy watering. Some of the depressions in yield reported may be the result of watering in the early stages, and of undesirable effects on soil structure. At no time, however, was more water applied than the soil would theoretically hold, and on only a few occasions did sufficient rain fall immediately after irrigation to cause drainage; it is unlikely that the observed effects were caused by leaching of nutrients. Experiments to elucidate possible effects of watering in the early stages, and of leaching, are planned for 1958. In addition, the main treatments are being modified so that water will not be applied to young seedlings and, during the growing season, the soil will not be restored to field capacity to its full depth.

The results, in general, show that while most crops can benefit from irrigation, it is desirable to vary the watering treatment at different stages of crop growth, instead of maintaining a rigid watering system throughout the life of the crop.

IRRIGATION OF SELF-BLANCHING CELERY (G. Stanhill)

During the summer of 1957, an experiment was carried out in the glasshouse with self-blanching celery. Plants raised in the usual manner were transplanted into 5-gallon bitumened metal soil containers in which they were grown to maturity.

The following watering (*W*) and nutritional (*N*) treatments were combined factorially :—

Treatment W 1 Watered at approximately 5-day intervals to restore soil to field capacity.

Treatment W 2 Watered at approximately 3-day intervals to restore soil to field capacity.

Treatment W 3 Watered daily to restore soil to field capacity.

Treatment N 1 Grown in John Innes potting compost without base fertiliser.

Treatment N 2 Grown in John Innes potting compost with half the normal quantity of base fertiliser.

Treatment N 3 Grown in John Innes potting compost with the normal quantity of base fertiliser.

With the wettest treatment, although the soil was restored to field capacity every day, it is likely that the plants were subjected to appreciable moisture stress because the containers limited the volume of water available to the roots.

The highest yields were obtained at the highest levels of nutrition and of water supply (Table II). Increase in water supply had its largest effect on yield at the highest level of nutrition; similarly the effect of increased nutrient supply on yields was intensified as the water supply was increased.

TABLE II

The effects of different nutritional and watering treatments on yield of self-blanching celery grown in containers; grams per plot of nine plants.

Watering treatments	Levels of nutrition			Total
	*N*1	*N*2	*N*3	
*W*1	1440	1775	1589	4804
*W*2	1534	1728	1665	4927
*W*3	2123	2226	2537	6886
Total	5097	5729	5791	

L.S.D. (P.=05) for comparisons of the individual treatments ±69
L.S.D. (P.=05) for comparisons of the totals ±40

In a field experiment with self-blanching celery, the effects of different combinations of soil moisture conditions at planting time and after planting were compared during the 1957 season.

Treatment at planting (1) Plants set in soil at 3-inch moisture deficit.
(2) Plants set in soil brought, by irrigation, to field capacity.

Treatment after planting (*a*) No water was applied other than rain.
(*b*) The soil was irrigated each day with the same volume of water as had been lost during the previous 24 hours, as estimated from meteorological data.

The yield of trimmed produce was positively correlated with the total amount of water applied (in addition to rainfall) irrespective of the time of application. A single heavy application prior to planting gave a small increase in yield and although a small additional increase in yield resulted from treatment 1.*b*., it did not justify the cost of giving light applications every day. Further work is required on this crop before final conclusions can be drawn.

IRRIGATION OF CAULIFLOWERS (P. J. Salter)

In the field

Results obtained in previous experiments at Wellesbourne indicated that the growth rate and yield of Finneys 110 early summer cauliflower were adversely affected when 50 per cent of the available water in the root zone had been depleted before irrigation was applied. Maximum growth rate and yield were obtained when the soil was restored to field capacity every day (4). A further experiment was carried out in 1957 to determine more precisely, in terms of depletion of available water, the point at which growth was adversely affected.

Pot grown plants of the variety Finneys 110 were planted out on 15th March into soil at field capacity. The following treatments were started immediately and were maintained until the crop was cut. Plots were not covered, but there was little interference with treatments by rain.

Treatment A The soil was restored to field capacity every day by adding an amount of water equal to that evaporated and transpired the previous day.

Treatment B Sufficient water was added to restore the soil to field capacity whenever the available water in the root zone had been depleted by 25 per cent.

Treatment C Control; the plants received rain only.

At harvesting the same person judged when each curd was ready for cutting. There was no significant difference in respect of untrimmed and trimmed fresh weights, curd size, and leaf area of plants given treatments *A* and *B*, while all the above measurements from plants given treatment *C* were significantly smaller ($P<0.01$) than those from plants given treatment *A* or *B*.

These results suggest that, in order to increase yield under the conditions of this experiment, it was not necessary to irrigate until at least 25 per cent of the available water in the root zone had been depleted.

In the propagating frame

The effect of soil moisture conditions during the propagating stage on growth and final yield of autumn sown, early summer cauliflower has been studied. Young plants of the variety Finney's 110 were subjected to a wet or dry soil moisture treatment from 6th October 1956 until 13th March 1957 when they were planted in the field. Plants subjected to a wet treatment were watered daily, whilst with plants subjected to a dry treatment the soil was allowed to dry to wilting point before being irrigated. After planting out, half of each batch of plants was watered daily with a volume of water equal to the previous day's evapo-transpiration loss, calculated according to a modification of the Penman method. The other half of each batch received no water other than rainfall.

At harvesting, plants kept dry during the propagating stage produced significantly smaller curds ($P<0.01$) than plants kept wet during this period, irrespective of the subsequent (field) watering treatment. The dry treatment during the propagating stage caused a significantly greater number of plants to 'button'* ($P<0.01$) than the wet treatment. When dry conditions in the propagating stage were followed by dry conditions in the field, 33 per cent of the plants buttoned, and the interaction of the two dry treatments was highly significant ($P<0.01$). Thus, soil moisture conditions during the propagating stage can greatly influence the subsequent growth and yield of early summer cauliflowers.

*A 'buttoned' cauliflower is regarded as one which has produced a small curd, just before or soon after planting out, as distinct from small curds produced at or near to the usual time of harvest.

GROWTH STUDIES ON THE CAULIFLOWER (P. J. Salter)

A study of the growth and development of the cauliflower was started in 1957 to provide information on which to base experimental work on the water relations of this crop. The growth rate of various organs of the plant was measured in terms of increment of fresh weight, dry weight and linear measurements. Experiments were done to determine the influence of environmental factors, including temperature and soil moisture, on curd initiation. It was shown that blindness could be caused in early summer cauliflower by subjecting the plants to a cold period at a certain stage of development prior to transplanting, and a detailed account has been published elsewhere (5). Further work is proceeding to determine the duration and intensity of cold necessary to produce blindness.

FURTHER STUDIES ON THE LOSS OF WATER FROM PLANT/SOIL SYSTEMS (G. Stanhill)

In 1957 replicated sets of weighable and drainage lysimeters were installed, similar to those previously described (3), enabling comparisons to be made between the rates of water loss from two different crops growing under the same environmental conditions. In order to distinguish the effects of plant and soil factors on water loss from the effects of fluctuating weather conditions, it is convenient to express the rate of water loss as relative to that of evaporation from an exposed open water surface adjacent to the crops. This ratio will be referred to as the 'relative water loss'.

1. *Plant factors.* The relative water loss from a carrot crop increased with increasing plant cover until 40 per cent of the soil surface was covered by foliage.

Thereafter the relative water loss remained constant and was unaffected by further growth. It was observed that, as in previous experiments, the point at which further increases in plant cover did not increase the relative water loss coincided with the date when the shape of the leaf canopy was such that all direct sunlight was prevented by the leaves from reaching the soil.

After this point had been reached there was a large and consistent difference between the relative water loss from the carrot crop, and that from a short grass crop completely covering the ground (Table IV). This finding does not support the view that evapo-transpiration is the same for all species under the same conditions.

TABLE IV

Relative water loss from short grass and from carrots (August–October 1957)

Crop	Soil watered daily (drainage lysimeters)	Soil receiving rainfall only (weighable lysimeters)	Mean
Grass	1.00	0.67	0.84
Carrots	1.75	0.84	1.30
Mean	1.38	0.76	

2. *Soil factors.* The reduction in the growth rate of both carrots and grass caused by soil moisture deficit was found to be proportional to the reduction in the rate of evapo-transpiration. It is noteworthy that when, as in this experiment, the roots of both crops occupied identical volumes of soil, they reacted in a similar manner to soil moisture deficits.

Evapo-transpiration from grass maintained at field capacity was 22.15 inches during the 1957 Shaw year (November 1956–November 1957), whereas that from the grass which received rainfall only was 17.15 inches ; the summer soil moisture deficit had reduced the evapo-transpiration.

3. *Seasonal factors.* Statistical study of the year's data showed that 85 per cent of the variance in the weekly amount of evapo-transpiration from grass with unrestricted soil moisture supply could be removed by allowing for the variance observed in the water loss from an evaporation tank. There was no evidence that the remaining deviations were correlated with the height of the grass. There was only slight evidence of a seasonal change in the relative water loss similar to that found at Rothamsted (2). It is suggested that possible inaccuracies in the measurement of rainfall (6) could cause inaccuracies in computing water loss from field measurements, and hence apparent differences between relative water loss during the winter months and the summer months. Comparison between values for measured evapo-transpiration and incident solar energy confirmed the lack of any seasonal change in relative water loss, and it was calculated that throughout the year a constant proportion of the incident energy (46 per cent) was used in evapo-transpiration.

4. *The likelihood of irrigation need.* When calculating the water requirements for irrigation, the extent of year-to-year variation in water need is of importance. Hitherto (1) this variation has been calculated from the variance of summer rainfall, and the year-to-year variance in amount of water loss and the co-variance between rainfall and water loss have been neglected.

30 years' records of rainfall and evaporation at five widely separated United Kingdom stations showed that the per cent standard deviation in the annual amount of evaporation was two-thirds that of rainfall.

70 years' data from one station was used to calculate variances in monthly evaporation, rainfall and calculated soil moisture deficit. There was no seasonal trend in rainfall variance but there was a marked increase in evaporation and soil moisture

deficit variance during the four winter months. There was also a high, statistically significant ($P<.01$), negative correlation between the amounts of rainfall and evaporation during the six summer months. The standard deviation of the maximum soil moisture deficit which occurred each year was 67 per cent.

These results suggest that the variance in irrigation need may have been underestimated in the past by neglecting the variance in water loss from evapo-transpiration and the negative correlation between this water loss and rainfall during the summer months.

Acknowledgments

We wish to thank the Directors and staffs of the E.H.S. at Luddington, Stockbridge House and Efford for carrying out the experiments on the irrigation of a rotation of vegetable crops ; these experiments involved the E.H.S. staff in an unusually large number of measurements and calculations, and we are grateful for their co-operation in this work.

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ENTOMOLOGY REPORT

By D. W. WRIGHT

During 1957 work has been continued and expanded on projects which have mostly been under investigation for several years. Reports on these are given below.

BIOLOGY AND NATURAL CONTROL OF CABBAGE ROOT FLY
(R. D. Hughes, Dorothy D. Salter and B. Mitchell)

The high temperatures of February and March 1957 caused an unusually early first appearance of cabbage root flies (1st April), and emergence continued for about a month. A prolonged egg-laying period followed, which merged with that of the second generation. Soil sampling for larvae showed that the successful development of the first generation was confined to two groups of individuals which differed in age by about three weeks. This splitting of the first generation was reflected in a double second generation, and egg-laying was continuous throughout the summer.

Root fly larvae killed approximately 34 per cent of unprotected Primo cabbages planted out in mid-April, but the attack was less serious on the summer transplanted crop. As in 1955, treatment of the soil with certain insecticides, broadcast at low rates, again resulted in increased root fly infestation, and lower yields of cabbage.

Emphasis has been given to the study of the biology and population changes of both cabbage root fly and the associated complex of predatory beetles. The latter appear to be a major cause of large egg losses which occur daily from around plants. These losses necessitate a reappraisal of any conclusions concerning the total number of eggs laid when this is based on egg counts taken at intervals of several days.

A more efficient technique for studying beetle populations in the field has been developed by using large numbers of pit-traps. This has shown that beetle species occur in succession during the growth of a cabbage crop. Certain species are associated with open habitat conditions which follow transplanting, whilst others show marked preferences for shade conditions and are chiefly found in the well developed crop.

THE CONTROL OF CARROT FLY (D. W. Wright)

Field experiments to determine the relative effectiveness of persistence of aldrin, dieldrin and gamma BHC when used in the soil for the control of carrot fly, have been continued. Aldrin incorporated in the top four inches of soil in 1955 at rates of 2 lb. and 4 lb. per acre still gave a complete control of carrot fly on maincrop carrots at Wellesbourne in 1957. Both treatments gave similar results in 1955 and 1956. Gamma BHC used at rates of $\frac{3}{4}$ lb. and $1\frac{1}{2}$ lb. in 1955 was much less effective in 1957 than either of the aldrin treatments, the lower rate of gamma BHC giving little control.

On medium sandy loam at Wellesbourne and on fen soil at Chatteris, early and late sown carrots and parsnips were grown in 1957 on plots where the top four inches of soil had been treated with insecticides in the previous year. At Wellesbourne, complete or almost complete control of carrot fly occurred on all crops where the following insecticide treatments had been used : gamma BHC 2 lb. per acre, aldrin 2 lb. and 4 lb. per acre and dieldrin at 1 lb., 2 lb. and 3 lb. per acre. Where gamma BHC had been applied in 1956 at 1 lb. per acre the control was less complete. The carrot fly attack on the untreated plots averaged 50.4 per cent and 72.5 per cent for the carrots and parsnips respectively. At Chatteris all treatments were somewhat less effective, the average infestation on carrots, assessed in November was 27.0, 16.1 and 6.3 per cent for gamma BHC, aldrin and dieldrin respectively, each chemical having been used in 1956 at the rate of 4 lb. per acre. Where half this rate of application had been used the lowest infestations followed the use of dieldrin. Seventy-seven per cent of the carrots on the untreated plots at Chatteris were infested. On parsnips all

three chemicals caused reduction in carrot fly attack but the effect was most marked with dieldrin.

Experiments were carried out in 1957 on fen soil to determine the effects of different concentrations of insecticide and the depth of its application in the soil, on carrot fly control. These showed that, using dieldrin, incorporation in the soil two to four inches or four to six inches below the surface were both more effective than the same amount of insecticide mixed in the top two inches of soil. Treatment of the top four inches of soil gave the most complete control. The effect of different concentrations of dieldrin in the top one inch and top four inches of soil were explored in another experiment. Concentrations of 1 p.p.m., 1½ p.p.m. and 2¼ p.p.m. of insecticide in the soil were all found to be equally effective (1 p.p.m. is approximately equivalent to 1 lb. per acre incorporated into the top four inches of soil). All concentrations in the top one inch of soil, however, were much less effective in controlling carrot fly than the corresponding four inch depth treatments.

EFFECT OF INSECTICIDES ON CROP FLAVOUR
(D. W. Wright and Dorothy D. Salter)

Tasting tests have been carried out on carrots grown in field plots, the soil of which had been treated with insecticide to a depth of four inches in either 1955, 1956 or 1957. On medium sandy loam soil at Wellesbourne, gamma BHC at ¾ lb. and 1 lb. per acre caused off-flavour in carrots for two seasons after application. Used at 1½ lb. per acre the effect of the gamma BHC persisted for three seasons but declined in intensity over that period. On the same soil type, aldrin and dieldrin used at rates of up to 2 lb. per acre generally caused slight loss of flavour or sweetness both in the year of application and in the following year. With aldrin at 4 lb. per acre the effect was somewhat greater. No tainting of carrots has been recorded following the use of aldrin or dieldrin in the soil at Wellesbourne.

On fen soil at Chatteris, aldrin and dieldrin at 4 lb. and 2 lb., respectively, caused no effect on carrot flavour in the second year after application. In the first year, however, both caused slight loss of flavour. Gamma BHC at 4 lb. per acre, which heavily tainted carrots in the first year of application, caused loss of flavour but no taint in this crop in the following year.

Carrots grown in fen soil treated in May 1957 with dieldrin at the rate of 2 lb. per acre were canned and assessed for quality by an experienced panel at a Cannery. They were found not to be different in flavour, texture or in any other quality from the carrots grown in untreated soil in other parts of the same field.

LETTUCE ROOT APHID (J. A. Dunn)

In 1957 the numbers of lettuce root aphid galls on the poplar trees within seven miles of Wellesbourne were extremely low and although in this area the sites of several hundred poplars are known, difficulty was experienced in obtaining sufficient material for laboratory and field work.

The lack of galls on poplar was reflected in the smallness of the aphid infestations on the roots of lettuce on the experimental plots at Wellesbourne. However, the distribution of root aphids was sufficiently uniform on these plots, to enable conclusions to be drawn on the relative effectiveness of the various insecticide treatments.

The most successful treatment was an endrin seed dressing followed by a 0.2 per cent endrin band spray, applied to the foliage just after the lettuce had been singled. Endrin seed dressing (equal weights of a 50 per cent endrin dust concentrate and lettuce seed) or endrin spray when used separately were less effective, but when used together the amount of dressing could be halved without significantly reducing the control. Thimet 44D seed dressing was inferior to endrin seed dressing and gave inadequate control of root aphids.

Further experiments were carried out on the effect of storage on viability of endrin-dressed lettuce seed. Endrin 50 per cent dust concentrate was used at two different

rates ; at equal parts by weight of seed and at half this amount. The germination capacity of seed treated at the lower rate declined by 20 per cent after 103 days of storage whereas a similar fall in germination was reached after only 60 days at the high rate of dressing.

A study is being made of the influence of temperature on the longevity of wingless root aphids. This aspect has particular bearing on the survival of the aphid in soil in the absence of living plant-host material. Wingless aphids have been kept in moist soil at a series of temperatures between 38 and 80°F. and survival records obtained. If these findings are applied to the weekly mean temperatures recorded in the soil at Wellesbourne at a depth of four inches, it can be inferred that it would have been possible for root aphids to have survived in soil and without feeding for the six months period from October to March in each of the past seven years.

CARROT FLY ON PARSNIPS (G. A. Wheatley and J. A. Hardman)

In order to provide further information on the biology of *Psila rosae* F. attacking parsnips, samples of this crop were examined twice weekly from the middle of July 1956 until the end of January 1957. At Wellesbourne, mining of the roots by the first generation of larvae occurred mainly during the last week of July and the first week of August, much later than had been expected. The mines produced by these larvae were found to heal rapidly during August and September so that by October they were difficult to detect. However, mining by the second generation larvae was on the increase by mid-October, approximately three weeks earlier than had been found to occur in 1954 and 1955 (1 and 2). The observations confirmed those previously noted, namely that the mining in the main root of the parsnip is done mainly by the more mature larvae (2). The fact that mines heal rapidly during August and September makes it essential that sampling for first generation attack should be completed before the end of August.

Several field experiments were carried out to investigate the efficiency of dieldrin as a seed dressing and as a spray applied to the soil either in June, after singling the crop, or in July and/or August. A seed dressing of 1 oz. of actual dieldrin per 1 lb. of seed gave an estimated 84 per cent control of the second generation of carrot fly larvae. A similar degree of control was obtained with a spray of 0.1 per cent dieldrin applied at 50 gallons per acre to the soil along the rows immediately after singling. When the latter treatment was supplemented by either one or two sprays of 0.1 per cent dieldrin applied at 100 gallons per acre to the soil along the rows during late July and/or early August, the degree of control obtained was increased to 96 and 99 per cent respectively. A third spray gave little further improvement in control.

An investigation of the effects of concentration of insecticide and rate of application showed that little could be gained by using concentrations greater than 0.1 per cent, or rates of application in excess of 50 gallons per acre for any one spray. The timing of sprays applied in July and August was found not to be critical, provided that at least one spray had been applied by the end of July and any further spray by mid-August. During the wet summer of 1956, the efficiency of dieldrin sprays applied to the soil was not improved by earthing up the rows immediately after spraying. This was contrary to the findings of the previous season (2) and it seems probable that earthing up may be beneficial only in a dry season.

The importance of getting a good stand of parsnips was clearly demonstrated by an experiment in which the crop was grown at six different spacings (8″, 16″ and 32″ row widths by 6″ and 12″ singling distances). Approximately 60 per cent of the roots grown at the closest spacing (8″ by 6″) were attacked by carrot fly compared with 77 per cent at the widest spacing (32″ by 12″), and the latter roots were three times more heavily damaged. The experiment has provided fundamental information on the relationships existing between plant spacing, the proportion of roots attacked and the amount of damage on the roots thus making it possible to devise more logical and better sampling techniques and thereby to interpret more accurately the results of field experiments on control of this pest.

PEA MOTH (J. A. Dunn and G. A. Wheatley)

Further studies were made on the influence of temperature on the diapause of overwintering pea moth larvae. A supply of freshly formed cocoons was obtained at the end of August 1956 from peas grown at Wellesbourne. Some of these cocoons were placed in an insectary and a continuous record of the ambient temperature obtained. Batches were transferred at intervals to constant temperatures suitable for morphogenesis and it was found that, under insectary conditions, the larvae were no longer in diapause by the middle of January. The remaining cocoons were used to determine more precisely the temperature requirements necessary for the completion of diapause development.

In order to determine the temperature characteristics of a collection of cocoons received from the Pea Growing Research Organisation Limited, Yaxley, some of the material was placed in constant temperatures in the laboratory and the remainder was used in field plots to study the emergence of the moth outdoors. Unfortunately, a high incidence of both eelworm and fungal parasites within these cocoons so reduced the emergence of the moths that the results were obscured.

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A COMBINED TREATMENT FOR THE CONTROL OF CABBAGE ROOT FLY AND WHIPTAIL IN SUMMER CAULIFLOWERS

By D. W. WRIGHT

In slightly acid or neutral soil conditions at Wellesbourne cauliflowers may develop moderate or severe symptoms of a condition called "Whiptail". This condition is known to be due to the deficiency of molybdenum, a trace element essential for plant growth (1). Although some reduction in the symptoms may be obtained by applying a molybdate to the soil before transplanting, experiments have shown that at Wellesbourne an almost complete control may be obtained by watering the plants with a solution of sodium molybdate shortly after setting out or, in the case of plants being raised in pots, a few days before transplanting.* In both cases the timing of the treatment coincides with that recommended for the control of cabbage root fly (2, 3, 4). Experiments have shown that molybdate and insecticide may be used in the same solution, each being fully effective.

Results of an experiment in which the mixture and its two components were used separately on summer cauliflowers are shown in Table I. The plants were raised in seed trays, transplanted on 28th March and, except for treatment 7, were treated the following day. The plants in treatment 7 were watered with a sodium molybdate solution ten days before transplanting at the rate of one gallon of solution per six square feet of seed tray area. With all other treatments the liquids were applied to the soil around the stem at the rate of one-eighth pint per plant. There were three plots of each treatment and 40 plants per plot.

TABLE I

Control of cabbage root fly and whiptail in summer cauliflowers—Wellesbourne 1957

Material and concentration	Total number of plants showing whiptail symptoms	Average weight per plot of marketable heads lbs.	% reduction in yield compared with treatment 1.
1. Dieldrin 0.03% Sodium molybdate 0.03%	0	58.4	0
2. Dieldrin 0.03% Sodium molybdate 0.06%	0	57.3	1.9
3. Dieldrin 0.03% Sodium molybdate 0.12%	0	58.8	−0.7
4. Dieldrin 0.03%	96	27.5	53.0
5. Sodium molybdate 0.03%	0	39.7	32.7
6. Control (water only)	114	8.6	85.3
7. Sodium molybdate 0.03% applied to seed trays	17	40.3	31.1
Difference required for significance (p=0.05)	—	12.09	—

On all plots where no sodium molybdate had been used, many plants developed severe whiptail symptoms and became blind or produced no marketable heads. Others less severely affected gave small or poor quality heads. Where molybdate had been used, whiptail was almost or completely absent and good quality crops were harvested. No adverse effects or added benefits resulted from increasing the amount of sodium molybdate above a basic level thus indicating a considerable margin of safety in its use (compare treatment 1 with treatments 2 and 3). When used in the seed trays ten days before transplanting (treatment 7) the molybdate was not quite so effective as when used after transplanting but the affected plants showed only mild leaf symptoms which had little effect on yield (compare treatments 5 and 7).

Cabbage root fly caused a reduction in yield of approximately 32 per cent, a level of crop loss frequently caused by this pest on summer cauliflowers. Where both insecticide and molybdate had been omitted the yield of marketable crop fell by 85 per cent. Very similar results on the control of both whiptail and cabbage root fly on summer cauliflowers were obtained in 1956.

Plants of the same variety and age as those used in the previous experiment were also grown in 3-inch pots, prior to transplanting. The compost used was the same as that used in the seed trays and the plants were set out on land adjoining that used for the previous experiment. The amount of whiptail which developed, however, was comparatively slight, only 13.7 per cent of the plants being affected and the yield was not greatly reduced. Sodium molybdate and insecticide used as in the previous experiment but applied to the pots before transplanting at the rate of one-sixteenth pint per pot gave a complete control of both whiptail and root fly.

The difference in the amount of whiptail in the two experiments appears to be closely related to the amount of compost carried on the roots of the plants at the time of transplanting. Where this was considerable, as with the plants raised in pots, the amount of molybdenum in the compost was sufficient to carry the crop through to maturity with few whiptail symptoms. Plants from the seed trays, however, carried little compost on the roots and the molybdenum contained in it was insufficient to prevent whiptail from becoming severe. In both 1955 and 1956 less fertile and complete composts were used for propagation and severe whiptail developed on plants which had been raised in pots. In both seasons, however, treatment with sodium molybdate and insecticide before transplanting gave satisfactory control of both whiptail and cabbage root fly.

As the control of cabbage root fly should now be regarded as a necessary routine operation in the growing of summer cauliflowers the inclusion of sodium molybdate in the insecticide solution should also be looked upon in the same light by growers whose crops are liable to suffer from whiptail.

*It should be noted that cauliflowers may also suffer from a form of whiptail which is not brought about by a deficiency of molybdenum and, therefore, is not prevented by the use of this chemical.

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PLANT PATHOLOGY REPORT

By W. G. KEYWORTH

CROOK ROOT OF WATERCRESS (J. A. Tomlinson and Bridget R. Smith)

Preliminary field trials made in 1955-56 showed that zinc frit applied to watercress beds in October at the rate of 1 lb. per sq. yd. gave a considerable control of the disease during the winter months (1). This treatment was tested by growers in commercial beds in 1956-57. Two of the largest of these trials were made in Dorset and Lincolnshire in collaboration with the writers. In both trials the treatment reduced the amount of root infection from more that 95 per cent to less than 5 per cent. The yields from the treated beds were more than twice those from the untreated beds. Most growers who had used zinc frit in the recommended manner (2) reported an improvement in the vigour of the crop but a few reported some chlorosis of the plants. On investigation it was found that, in all but one of these instances, the chlorosis was not attributable to the frit applications, but any further reports of an adverse effect of the frit will be examined in detail.

Laboratory tests on the mechanism of disease suppression by zinc frit showed that the zoospores of the crook root fungus were killed if the water contained 1.0 p.p.m. zinc. It was further shown that zinc, in amounts sufficient to control the disease, was dissolved from the frit if the water contained approximately 20 p.p.m. of carbon dioxide produced by plants grown in the water. Tests in commercial beds not containing watercress showed that, although carbon dioxide was present in the inlet water, its concentration rapidly fell as the water flowed down the bed. In beds containing watercress, however, carbon dioxide was liberated into the water by the plants in amounts sufficient to dissolve enough zinc from the frit to control the disease.

Tests were made to determine whether the outflow water from beds treated with zinc frit was toxic to fish. Rainbow trout (*Salmo gairdnerii* Richardson) were kept in two cages for four months in the outlets of an untreated watercress bed and a bed which had been treated with zinc frit at the above rate. The beds were fed with soft water (80 p.p.m. total bicarbonate) and were chosen for the experiment because zinc has been shown to be more toxic to fish in soft than in hard water (3). The fish in both beds remained normal, those in the outflow water from the treated bed being apparently unaffected by the treatment. Since most watercress beds are fed with hard water and as rainbow trout are more sensitive to zinc than most fish, it was concluded that the use of zinc frit as recommended is unlikely to cause harm to fish.

MOSAIC DISEASE OF WATERCRESS (J. A. Tomlinson and Bridget R. Smith)

Further observations have confirmed that the vigour of green watercress is greatly reduced when infected with mosaic. As the virus causing the disease is not seed-borne (4) it can be controlled by raising new plants from seed. It has been found, however, that the common practice of allowing a bed of watercress to flower and harvesting the plants for seed when the oldest seed pods begin to ripen, should be avoided. Thus, on farms where this has been practised for several years, the early flowering of the crop has already become a serious problem, making much of the crop unmarketable. It has been recommended, therefore (5) that the early flowering plants should be rogued out so that seed is saved only from the late flowering plants.

Investigations into the factors affecting the flowering of green watercress, and the possibility of producing a hexaploid brown watercress from which seed can be obtained, are being made by the Plant Physiology and Plant Breeding Sections, respectively.

SILVERING DISEASE OF RED BEET (W. G. Keyworth and J. Sheila Howell)

Experiments on the control of this disease by seed treatment were continued in 1956-57, in particular to test the efficacy of mercurial dusts, since streptomycin remains unavailable to growers. The small scale experiments were not entirely satisfactory owing to low disease incidence in the plots grown from untreated seed, but they did indicate that several proprietary mercurial dusts were likely to be of equivalent value for seed treatment.

In a larger experiment, seed was treated with 'Harvesan', streptomycin, or erythromycin and sown, together with untreated seed, in August 1956 at Wellesbourne, Luddington E.H.S. and Paglesham. The individual treatment plots were spaced at distances of over quarter of a mile to reduce spread from plot to plot.

In March 1957, 200 plants were brought to the Research Station from each plot, and grown to maturity so that the incidence of silvering could be recorded. Of the plants grown from seed treated with streptomycin or erythromycin, 0.3 per cent and 0 per cent respectively were silvered but of those grown from seed treated with 'Harvesan' 8.5 per cent showed the disease. 21.7 per cent of the control plants grown from untreated seed were infected. It thus appears that the 'Harvesan' treatment was not as effective as previous results had indicated that it might be.

Observations have been continued on commercial crops grown from seed treated with mercurial compounds or streptomycin. These have also shown that although mercurial dust treatment of the seed gives a substantial measure of control it is not so effective as the streptomycin treatment.

In tests in which the concentration of streptomycin was increased to 0.04 per cent a few infected plants were found. Studies are in progress to determine whether these arose from seeds that had escaped the full action of the streptomycin or whether strains of bacteria were present which were resistant to the action of the compound.

STEM AND FRUIT ROT OF OUTDOOR TOMATOES (Dorothy E. Knight)

The main emphasis of the experiments in 1957 was on attempts to control the disease by applications of fungicides. It was hoped to test the effect of various fungicidal treatments on the natural spread of the disease and for this purpose large numbers of infected plants were interspersed among plots of treated plants. Very little spread occurred, however, even in the control plots and the main tests had to be made by artificial infection of the treated plants. In addition to the leaf scar tests described previously (6) the fungus and fungicides were applied to the base of the stem and the nearby soil in order to simulate the treatment of a natural infection (which usually occurs at or slightly below soil level). The timing of the application of the fungus and of the fungicides was adjusted so that the latter could be tested for their ability to eradicate the fungus when this was present first or to protect against its effects if it was put on afterwards.

Several dithiocarbamate compounds were tested and maneb was the best of them, both for eradicating the fungus if this was applied up to five days beforehand, and for protecting plants against it if it was applied up to five days later. Both treatments were more effective if further applications were given at three-week intervals. The lowest concentration giving a satisfactory control was one per cent of the pure compound.

Of the other fungicides tested, captan proved the most satisfactory as a protectant, but not as an eradicant. Three applications of a 0.25 per cent concentration gave a high degree of protection.

It is suggested that maneb could best be used on plants that have already been exposed to infection (e.g., near to known infected ones) where its eradicant properties would be most valuable. The protectant treatment with captan could then be given to other plants further away from an outbreak.

Further studies were made on seed transmission but no evidence was obtained that infected seeds give rise to infected plants. It was again shown, in more extensive trials than were possible in 1956, that a strain of *Lycopersicum hirsutum* var. *glabratum*

was highly resistant to stem and root infection by *Didymella*. Attempts to breed this character into *L. esculentum* are being made by the Plant Breeding Section.

PARSNIP CANKER (A. G. Channon)

Further studies have been made on the causes of this disease.

Through the co-operation of Regional Pathologists of the N.A.A.S. a survey was made of the occurrence of *Itersonilia* sp. on cankered parsnips obtained from many localities in England and Wales. Over 60 per cent of the roots, obtained from 53 places, yielded the fungus.

Forms of *Itersonilia* have been reported to occur on other plants, particularly in association with rust pustules and also on certain flowers. To test the possibility that these forms might be pathogenic to parsnips, isolations were made by the suspension technique (7) from diseased dahlia and chrysanthemum florets and from rust pustules on hollyhock and mint. Fungi were obtained that were of the same type as *Itersonilia* but which differed from the parsnip isolates in some morphological characters. In addition, none was pathogenic to parsnips in laboratory tests.

In the course of the survey mentioned above, parsnips received from five places were found to be infected with a species of *Phoma* which was probably the same as that described by Ogilvie and Mulligan (8). The fungus was isolated and proved to be highly pathogenic to parsnips. It caused a purplish black lesion that closely resembled the one caused by *Itersonilia*, but was often slightly darker. Occasionally pycnidia occurred in, or on the surface of the tissue.

Selection of plants showing resistance to canker has been continued within material derived from the stocks originally obtained from Mr. D. E. Green, Mycologist to the Royal Horticultural Society. Several lines have proved to be much less susceptible than a standard Offenham variety.

BOTRYTIS DISEASE OF LETTUCE (J. M. Way)

The trials of thiram, T.C.N.B. and other compounds against *Botrytis* disease of lettuce were continued for a third season in 1957. Thiram sprays again gave a good control of the disease on the frame crop, and T.C.N.B. dust worked into the soil before planting was almost equally effective. Contrary to the results in 1956 (9) however, T.C.N.B. dusted on to the plants did not greatly reduce the disease.

Botrytis infection was particularly severe on the spring-planted lettuce. Five or three sprays of the seedlings with thiram or captan before planting out gave good control of the disease. Five applications of T.C.N.B. dust also reduced infection.

CLUBROOT DISEASE OF BRASSICAS (A. G. Channon and W. G. Keyworth)

Experiments were made in 1956 and 1957 at Luddington E.H.S. to test the effect of aldrin on clubroot of Primo cabbage. The aldrin was applied to the soil either as dusts giving 2, 4 or 8 lb. active material per acre, or as spot treatments with emulsions giving (in 1956) 0.028 gm. and (in 1957) 0.11 gm. active material per plant. The same plots were treated in each year.

In 1956 there were no marked differences between the clubroot grades or yields of the plants receiving the different treatments. As the soil was acid (*p*H approx. 5.4) half of each plot was limed in 1957 to raise the *p*H by approximately 1.2. In this season, increasing doses of aldrin gave decreasing amounts of clubroot and, in the non-limed sections, increasing crop yields. The tests are being continued in 1958.

LEAF AND POD SPOT OF PEAS (R. B. Maude)

Research on this group of diseases caused by *Ascochyta pisi*, *Ascochyta pinodella* and *Mycosphaerella pinodes* was started in January 1957. During the first season the

work has been largely concerned with studying the distribution of the disease in the field, establishing suitable methods for the assessment of infection on seeds, and determining the effect of seed treatments on the disease. Considerable reduction in the numbers of infected seeds have been obtained by heat treatment in carbon tetrachloride but no treatment has given complete elimination of infection.

LETTUCE MOSAIC (J. A. Tomlinson and Bridget R. Smith)

In field trials of F_3 families being tested for their reaction to mosaic (10) visual assessment of the disease showed that its incidence in the various families varied from 0-100 per cent infection. When inoculated with sap from the leaves of the symptomless plants, healthy lettuce seedlings developed mosaic, indicating that these plants were symptomless carriers of mosaic. The susceptibility of the various families was tested by direct sap inoculation and a search was started for possible mosaic resistance in wild species of *Lactuca* supplied by the Plant Breeding Section.

Attempts were made to inactivate the virus in samples of infected seed by heat treatment at temperatures lower than those which killed the seed. It was found that the virus survived and gave rise to a small percentage of infected seedlings when seed was heated in air to 85° C. for one hour. Similar results were obtained when the seed was immersed in carbon tetrachloride (11) kept at 74°C. for one hour, or in water kept at 51°C. for 15 minutes or 45°C. for one hour.

BIG VEIN DISEASE OF LETTUCE (J. A. Tomlinson and Bridget R. Smith)

In May 1957, lettuce plants showing symptoms resembling those of Big Vein disease (12) were received through officers of the N.A.A.S. from a farm in Surrey. Visits were made by the writers to this and three other farms in Surrey where the same disease was seen. The most characteristic symptoms of the disease were chlorotic vein banding, and a 'puckering' or 'savoying' of the affected leaves.

The occurrence of the disease in Britain had previously been suspected (13) but had not been confirmed. Attempts were made, therefore, to establish its identity. Studies on the disease in the U.S.A. (14) showed that it could be transmitted by growing plants in soil to which root sap from diseased plants had been added, or in soil in which infected plants had been grown.

In experiments at Wellesbourne, 22 out of 30 plants developed Big Vein symptoms 54-90 days after the soil in which they were grown was watered with root sap from diseased plants. The disease was also transmitted to plants by growing them in soil collected from beneath affected plants from three farms in Surrey. The symptoms and the results of these tests, which were successfully repeated, indicate that the disease is Big Vein.

In October 1957, the disease was reported on a farm at Formby, Lancashire. In the same month the writers visited the area and observed Big Vein on lettuce plants on seven out of eight farms inspected.

Studies on the cause of the disease and possible control measures are now in progress.

Acknowledgments

Grateful acknowledgment is made of the help received from growers, officers of the N.A.A.S., and others, in the course of the research. Thanks are also due to those firms who have supplied materials for use in the trials.

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WEED INVESTIGATIONS

By H. A. ROBERTS

ECOLOGY (Marion E. Smart and H. A. Roberts)

Work was continued on the estimation of changes in the numbers of viable weed seeds present in the soil on plots of the long-term field experiments maintained by the Chemistry Section (5). As previously reported (6), the effect of the first year of vegetable cropping was to reduce the number of seeds in the top six inches of soil by rather more than 50 per cent. The results from samples taken in the autumn of 1955, after two years of cropping, showed that during the second year a further reduction took place, so that at this time the population was only 20 per cent of that present before the experiments began. There were, however, indications that certain species, notably annual meadow grass (*Poa annua*), had begun to increase on some plots of the cultivation experiment. A further series of samples has been taken from this experiment and during 1957 detailed counts of the weed seedlings emerging on the plots were made whenever possible. Samples of soil for weed seed estimation were also taken from the cultivation experiments sponsored by N.I.A.E. at Efford, Luddington and Stockbridge House E.H.S. at the end of the first three-year cycle of operations. Not all the plots were sampled, but six treatments were selected so that comparison with the results from the N.V.R.S. cultivation experiment would be possible.

The experiments on seed dormancy under field conditions described in previous Annual Reports were continued and extended so as to include several more weed species. Preliminary tests were also carried out on the viability of seeds of certain weed species at different stages of maturity.

The work on weed competition is now carried out by the Physiology Section, and is described elsewhere in this Annual Report.

CHEMICAL CONTROL (H. A. Roberts)

Further trials were carried out to determine the possibility of using dinoseb (amine) as a residual pre-emergence herbicide for weed control in large-seeded crops such as broad beans, runner beans and dwarf French beans. Rates of from 3 to 6 lb. per acre applied at any time between sowing and emergence had no adverse effect on crop yields and gave excellent control of annual weeds until harvest. It is realised that such high rates of application would be expensive, but it is envisaged that only a band over the crop row would be treated, relying on mechanical cultivation to remove weeds between the rows. Such a method would be particularly applicable to runner beans.

Dinoseb (amine) was also investigated as a post-emergence spray for field beans sown in the spring. Under the dry conditions experienced in 1957, 2 lb. per acre was significantly better than 1 lb. per acre and the highest yields, equal to those of plots kept clean by hand weeding, were obtained when spraying was done at an early stage when the beans had only one expanded leaf.

Further experiments were carried out with CIPC (isopropyl N-(3-chlorophenyl) carbamate) for the control of chickweed (*Stellaria media*) in machine-planted spring cabbage. It was found that an overall spray containing $\frac{1}{2}$ or $\frac{3}{4}$ lb. per acre applied shortly after planting gave good control throughout the winter. These rates of application caused some stunting of the crop in autumn, but the effects were outgrown and were not reflected in the final yield. Higher rates caused yield depression in most of the experiments. CIPC was also tested as a residual pre-emergence treatment to control chickweed and annual meadow grass in autumn-sown salad onions. At $\frac{1}{2}$ and $\frac{3}{4}$ lb. per acre, good control of both species was obtained with no adverse effect on crop yield. It would seem, however, that on the sandy loam at Wellesbourne, 1 lb. of CIPC is the maximum which can be applied under cool, wet conditions without causing yield depression.

Tests were carried out on salad onions with a contact herbicide, sodium monochloroacetate (1), in which applications were made at various growth stages. This herbicide effectively controlled many broad-leaved weeds but was without effect on annual meadow grass, a fact which seriously limits its usefulness on overwintered crops. It appeared to be more promising when used as a post-emergence treatment on young cabbage plants. Additional data were obtained from three trials, one at Wellesbourne, one at Luddington E.H.S. and one at Paglesham, to determine the effect of annual applications of monuron on the yield of established asparagus. To date, no evidence of any deleterious effect has been found as a result of applying 2 lb. per acre and tasting tests did not reveal any loss of flavour. Preliminary tests were also carried out on asparagus with simazin (2-chloro-4, 6-bis (ethylamino)-s-triazine) (4). This is a residual herbicide like monuron, but it is less soluble in water and is more persistent. The first applications were made in 1956 on a newly planted bed of two-year-old crowns and in 1957 further series of plots were sprayed. Excellent control of annual weeds has been obtained and so far there has been no apparent effect on the crop. It will be necessary to continue these experiments, however, before any conclusions can be reached. Simazin was also tested as a possible residual pre-emergence herbicide on sown vegetable crops. The majority of both crop and annual weed species were partially killed by a rate of $\frac{1}{4}$ lb. per acre and completely killed by $\frac{1}{2}$ lb. per acre, but parsnips appeared to show some degree of tolerance.

In co-operation with the A.R.C. Unit of Experimental Agronomy, plots were sprayed with various materials using a small-scale sprayer, built by the Unit, which utilises the logarithmic dilution principle (2, 3). Unfortunately, the dry weather interfered with this project, leading to sparse weed populations and uneven crop germination. Nevertheless, some information was obtained and useful experience gained in the operation of this type of sprayer.

Other work begun during the year included two trials, in co-operation with Stockbridge House E.H.S., on the eradication of horseradish, and a trial with residual herbicides for weed control in newly planted rhubarb. Glasshouse and field tests were also carried out with several herbicides which have recently become available in experimental quantities.

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STATISTICS REPORT

By J. A. NELDER

The consulting aspect of the Section's work has continued to be important, and the number of queries raised by members of other Sections has increased in the past year. Two of the topics required some detailed investigation which is described below. The design and analysis of experiments, missing plot formulae when several plot yields are missing, multiple regression, and transformations formed the subjects of most of the other queries.

The fitting of growth curves

Although there is a large amount of literature on the use of various mathematical expressions to describe the growth of plants, many problems connected with the subject remain unsolved. Some work on the competition between carrots and chickweed by Dr. Bleasdale at this Station has necessitated the fitting of curves to plant growth data, for the two species at different densities, alone and in competition with each other. The weather during this past summer (1957) has been highly variable, with extremes of sunniness ; examination of the data has shown that in these circumstances, the use of days as an independent variable against which to plot growth gives a misleading picture of the shape of the growth curve, and various time scales have been tried as giving a better indication of conditions for growth ; these included accumulated temperature, and various measures, direct and indirect, of radiation. A method of fitting the logistic curve to growth data has been worked out, though a number of problems, particularly as regards the speed of convergence of the iterative process used, need further investigation. Future biological and statistical investigations will be greatly helped by a special programme for the Rothamsted electronic computer, which has been written for us by Mr. S. Lipton ; this accomplishes the tedious business of fitting the logistic curve in a few minutes instead of the half a day which it previously took with a desk machine.

Designs for virus assays

Some work of Mr. Channon of the Pathology Section involving the assaying of a number of virus preparations on *Nicotiana glutinosa* has led to a consideration of suitable designs for such work. The 'plots' in these experiments are half leaves of the test plants, and various characteristics of the plants have to be taken into consideration in planning suitable designs. Thus it is known that there may be marked differences in sensitivity between different plants and between different leaves of the same plant, while comparisons between two halves of the same leaves are often more accurate than those between two halves of different leaves. A number of designs has been worked out for test plants of the *N. glutinosa* type, which have several leaves (usually at least four) available for the assay. In these designs, treatments are orthogonal to plants and leaf-position within a plant, and are balanced in pairs with respect to their occurrence on the same leaf. Suitable designs have also been worked out for test plants of the *Phaseolus vulgaris* type, which have only two leaves per plant available. Here treatments are balanced in pairs both for occurrence on different leaves of the same plant, and different halves of the same leaf. Such designs, which may be termed doubly balanced incomplete block designs, have been found for any number of treatments up to and including nine.

Statistical models for field experiments

What may be termed the standard model for the analysis of variance of, say yields in a field experiment, supposes that the yield can be regarded as made up of

components representing block and treatment effects plus an error term which is supposed to have a variance independent of the treatment. It frequently happens in practice that the variances are not independent of the treatments, and the model is customarily modified in text books to allow the error term to have different variances according to to treatment, while keeping the block component independent of treatment. Examination of data obtained at the Station and elsewhere shows that this model is frequently false, and that it can lead to marked over-estimation of standard errors if the usual form of analysis is followed. An alternative model, which agrees satisfactorily with the data obtained has been evolved, and its consequences are being further investigated.

FIELD EXPERIMENTAL TECHNIQUE (J. A. Nelder and D. Cooke)

Experiments under this heading have been carried out during the year on summer cauliflower, red beet, carrots, and peas.

The effect of sorting out cauliflower plants prior to planting and allocating equal proportions of each size grade to each plot was compared with the results obtained from planting out without such sorting. The variation in size of plants at planting-out was noticeably smaller in 1957 than in previous years, and this produced the expected effect of giving a smaller advantage to sorting than had previously been obtained. The variances of the total untrimmed weight and marketable trimmed weight were respectively 38 and 32 per cent higher in the unsorted than the sorted, and these differences, though in the expected direction, were not significant.

The effect of chitting the seed and of intensive weeding on the variability of red beet was investigated. Seed was chitted in damp sand until emergence of radicles had begun and then sown with a hand drill in the usual way. Intensive weeding was done twice as frequently as 'normal' weeding. Both treatments produced large effects on the total yield, chitting increasing it by 20 per cent, and intensive weeding by 25 per cent. The joint effect of both treatments reduced the percentage standard error significantly from 16.1 per cent to 10.6 per cent. Each treatment produced a 12 per cent increase in marketable weight, and the combined effect reduced the percentage standard error (again significantly) from 17.6 per cent to 12.6 per cent. The smaller percentage increases in yield for marketable weight arose chiefly from the rejection of large roots, which were themselves mostly the result of a low stand caused by dry weather. Chitting did not increase the final stand or reduce its variability (as measured by the percentage standard error) ; its effect on total yield came from the more rapid germination and establishment it permitted in the field.

Experiments on peas intended for canning and, particularly, for quick freezing, present certain technical difficulties connected with the fact that the harvest date is very critical. Two possible ways of dealing with this situation suggest themselves. Either every treatment can be harvested several times, a yield-time curve constructed, and the yield at the best stage of growth found by interpolation, or the plots can be sampled for stage of growth (as measured by tenderometer reading, etc.) and a single harvest taken for yield when the growth stage is optimum. The first method is wasteful of land and labour, while the second is unsatisfactory if the sampling method determining the single harvest date for a variety is subject to errors in determining harvest date even as small as 36 hours earlier or later than the true date. An experiment was carried out in 1957 in collaboration with the Chemistry Section to test this latter method, using the percentage of alcohol-insoluble solids (A.I.S.) as a measure of maturity. Two varieties, Laxton's Progress and Onward, and two sowing dates were used, and near maturity plots were sampled at 2-3 day intervals, using $8\frac{1}{2}$ ft. of row per plot. The contribution to the variance by the chemical side of the A.I.S. determination, given the sample, was small and unimportant, but the error introduced by the sampling procedure itself was considerable, and it was found that it would be necessary to take 50 ft. of row on each date in order to reduce the standard error of the A.I.S. determination to about one-half per cent, which is about the minimum accuracy required on which to base a single harvest decision. It would appear from

these results that the sampling method involving a single harvest for the whole crop is unlikely to work in practice, since it involves the growing of extra rows for sampling, whose area will be at least as great as that required to give the three or four yield determinations in the other method.

WORK FOR OTHER BODIES

Members of the Section continued to serve on several working Parties of the Agricultural Improvement Council's Experimental Horticulture Committee, J. A. Nelder on the Glasshouse and Protected Cropping Working Parties, and D. Cooke on the Bulbs and Flowers Working Parties. During the year the Section dealt with the analysis of 60 experiments for outside bodies. These involved 3,092 plots with an average of 2.7 variates analysed for each plot. 56 of the experiments were carried out on the E.H.S., while the remainder of the data came from other N.A.A.S. sources. Assistance with statistical problems has been given to members of the Glasshouse Crops Research Institute and the National Institute of Agricultural Engineering ; in particular D. Cooke has analysed a number of uniformity trials for the Glasshouse Crops Research Institute and has reported on the information they give about the accuracy likely to be obtained in future experiments with plots and blocks of various sizes and shapes.

THE WEATHER DURING 1957

RECORDS OF THE N.V.R.S. CROP WEATHER STATION

By JOSEPHINE I. E. RUBIO, E. J. WINTER and G. STANHILL

The distribution of rainfall during 1957 was similar to that in 1956, giving a dry spring followed by a wet summer and autumn. Rainfall during the first six months of 1957 totalled only 8.05 inches ; the average for this six-month period is 10.67 inches.

Exceptionally high rates of evaporation and transpiration were recorded during June 1957. On nine days the measured evaporation from an open water surface exceeded 0.20 inch per day, on four days it exceeded 0.30 inch, and on 18th June it was 0.36 inch. The total for June 1957 was 5.35 inches. At Camden Square, London, where evaporation measurements have been made for 70 years, the highest monthly total ever recorded was 4.86 inches. The measured water loss from grass watered daily, i.e., potential evapo-transpiration, exceeded 0.20 inch on ten days during June 1957.

The use of a special raingauge with its rim only one inch above ground (1) was continued in 1957. Rainfall collected by this 'ground level' raingauge totalled five per cent more than that collected by the standard gauge with its rim 12 inches above ground, and the magnitude of the daily difference in readings was found to be related to wind speed. These results confirmed observations made in 1956 (1).

The effect of the height of a gauge above ground on amount of rainfall collected was also studied, using six gauges with rims at different heights from one inch to six feet. There was a linear relationship between log. height of measurement and the amount of rain collected. The slope of this line was dependent on the daily run of wind. Even when the run of wind was as little as 25 miles per day, measured 12 inches above ground, the ground level gauge collected more rain than the standard gauge 12 inches above ground. These results suggest that, except in the most sheltered areas, rainfall measured at the standard height is seriously under-estimated by an amount dependent upon the run of wind (2).

The weather records for 1957 and the winter of 1956-57 are summarised in the following tables and figure.

TABLE I

Summary of various weather features during 1957

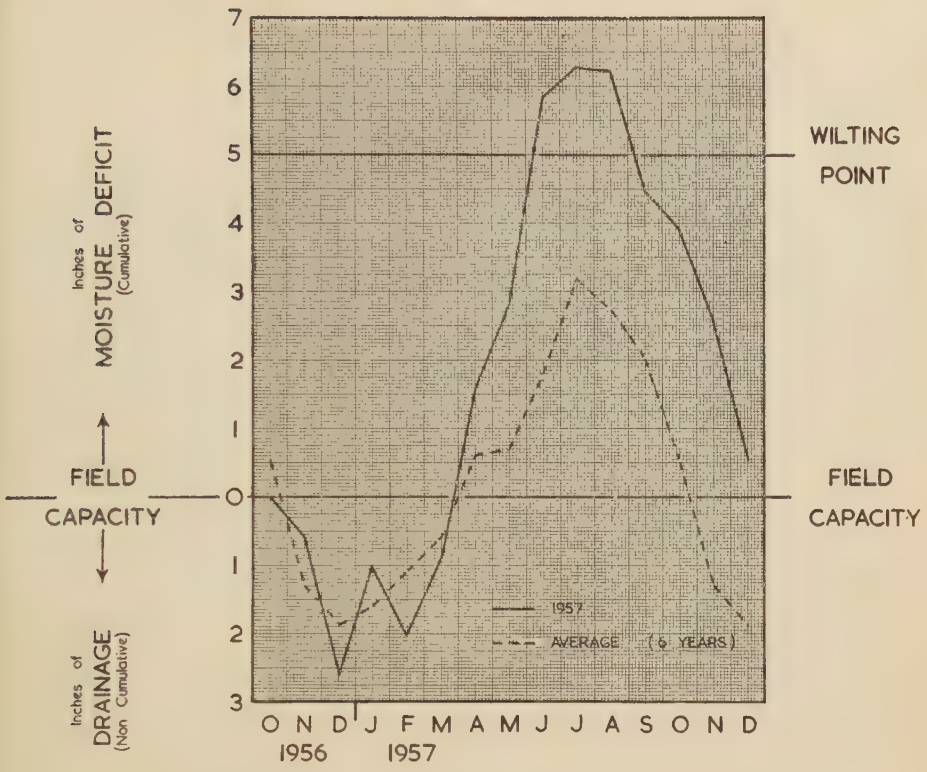
			*7-year average
Sunshine :	sunniest month	June (daily average 9.5 hours)	5.7 hours.
	dullest month	January (daily average 1.5 hours)	1.5 hours.
	most in a day	14.9 hours on 14th June (89% of possible).	
Rainfall :	wettest month	September (3.05 inches)	1.99 inches.
	driest month	April (0.21 inches)	1.25 inches.
	most in a day	0.66 inch on 23rd September	
	total during 1957	21.14 inches	23.95 inches.
Wind :	windiest month	January (daily average run—197.41 miles)	145.11 miles.
	calmest month	October (daily average run—99.26 miles)	99.15 miles.
	windiest day	10th December (day's run—331.98 miles)	
	calmest day	9th October (day's run 10.19 miles)	
	daily average run of wind during 1957—135.51 miles.		
Air temperature :			
	warmest month	63°F. mean temperature in July	61°F. (6-year average)
	coldest month	39°F. mean temperature in December	41°F. (6-year average)
	highest maximum ...	88°F. on 28th June.	
During winter 1956-57 :			
	lowest minimum	19°F. on 22nd and 23rd November 1956, i.e., 13° of frost.	
	first air frost	29°F. on 26th October 1956.	
	last air frost	27°F. on 6th May 1957.	
	number of nights with air frost—49		73
	number of nights with ground frost—82		105

*The averages refer to the corresponding month or period during the previous seven years. Thus, in the first entry in the table, the average daily number of hours of sunshine for June during the past seven years was 5.7, but June was not necessarily the sunniest month in every year.

TABLE II

Observations made at N.V.R.S. Crop Weather Station during 1957

Month	Air temperature °F.		Number of frosts		Mean soil temperature °F. at 0900 hr. G.M.T.			Rainfall		Total sun hours	Total solar radiation. Gm. calories	Mean daily run of wind. Miles.	Evaporation from water surface. Total inches	Evapo-transpiration from grass surface. Total inches
	Mean Max.	Mean Min.	Air	Ground	4″	12″	48″	Total inches	Number of days with rain					
January ...	47	36	9	13	38.8	40.3	42.5	1.32	15	46.2	1550	197.41	0.04	0.59
February ...	48	35	11	18	38.8	41.0	43.1	2.32	17	76.7	3157	131.10	0.38	0.35
March ...	56	41	5	7	45.2	46.3	45.1	1.90	15	93.6	5263	138.64	1.07	1.15
April ...	57	40	1	6	48.8	49.0	48.6	0.21	4	156.2	9114	147.64	2.44	1.94
May ...	60	41	2	7	54.0	52.7	51.4	1.27	9	189.9	12173	144.54	3.49	3.01
June ...	72	48	0	1	64.1	61.7	57.3	1.03	10	284.7	15462	124.25	5.35	5.51
July	70	56	0	0	63.9	64.2	61.7	2.60	20	129.5	10487	121.87	3.32	3.08
August ...	68	53	0	0	61.3	62.2	61.5	2.56	16	138.7	8813	131.20	2.92	2.92
September ...	61	48	0	1	54.5	56.5	57.8	3.05	17	101.2	5885	132.84	1.79	1.51
October ...	59	43	1	0	49.2	51.6	53.6	1.20	12	74.3	3147	99.26	0.79	0.76
November ...	48	37	6	6	41.0	44.0	48.6	1.51	8	64.6	1917	111.42	0.53	0.35
December ...	45	33	13	14	37.5	39.6	43.7	2.17	16	48.9	1207	145.94	0.17	0.25
Total 1957 ...	—	—	48	73	—	—	—	21.14	159	1404.5	78175	—	22.09	21.42
7-year average ...	—	—	—	—	—	—	—	23.95	170	1401.3	—	—	—	—



Theoretical moisture status of a soil completely covered with a green crop.

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LIBRARY REPORT

By BARBARA M. MOORE

The library was without a full-time librarian for half the year and routine work continued with the part-time help of the retiring librarian and other members of staff. Borrowing from other libraries was suspended temporarily, as also was the indexing of publications received. The binding of journals was continued and is now nearly up to date. 118 volumes were bound during the year.

Library accessions included, 21 books bought during the year, three journals taken for the first time and 302 separates received. Holdings are now as follows :—

Current periodicals	129
Bound periodical volumes	626
Books	255
Separates	2,347

Reports from other organisations are not included in the figure for separates ; 66 of these were received during the year. A geographical reclassification of this material was begun.

The Agricultural Research Council approved a contingency grant to meet the cost of purchasing much needed basic text and reference books.

Loans obtained from other libraries numbered 198, while internal loans maintained a steady figure.

PUBLICATION RECORD

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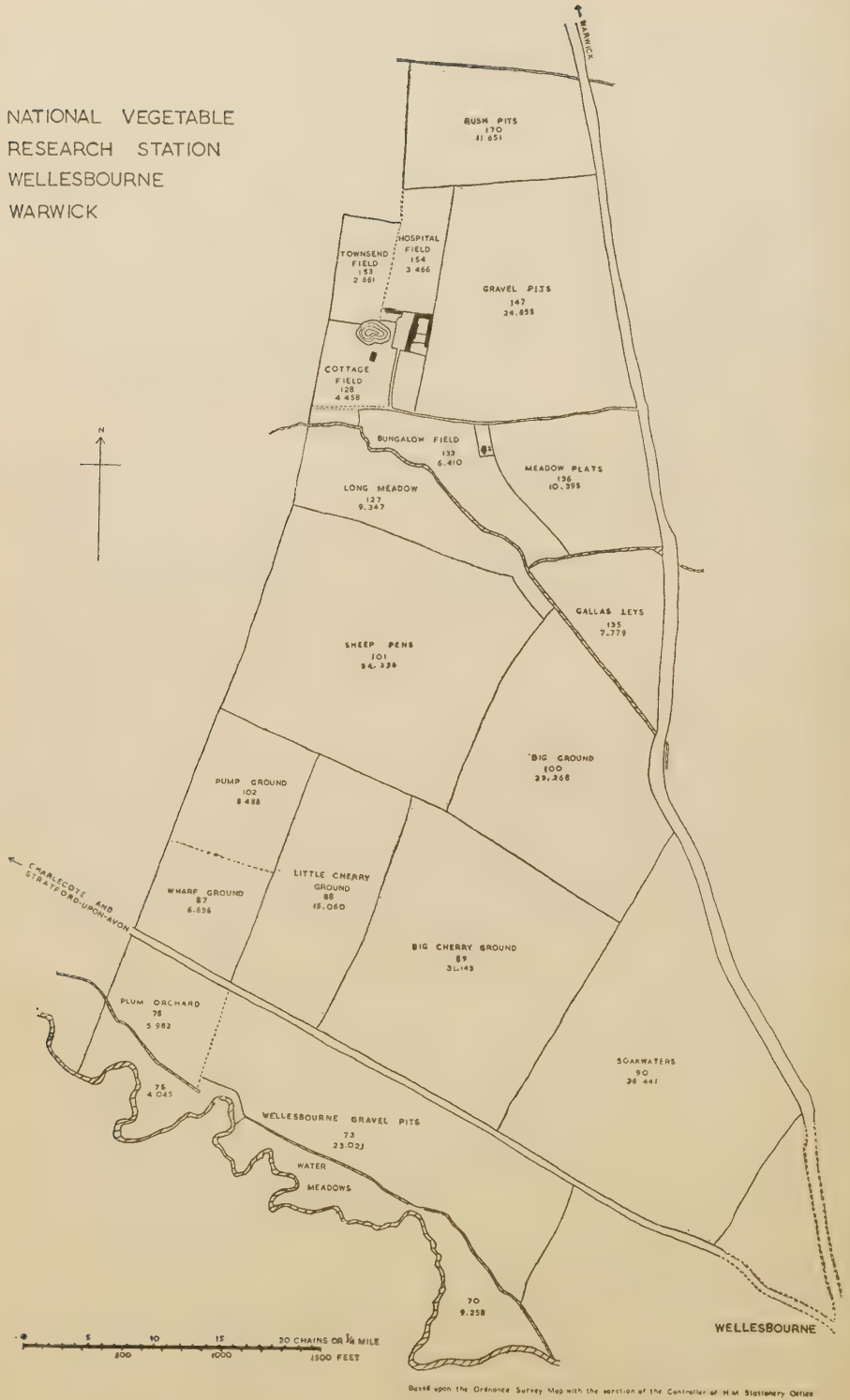
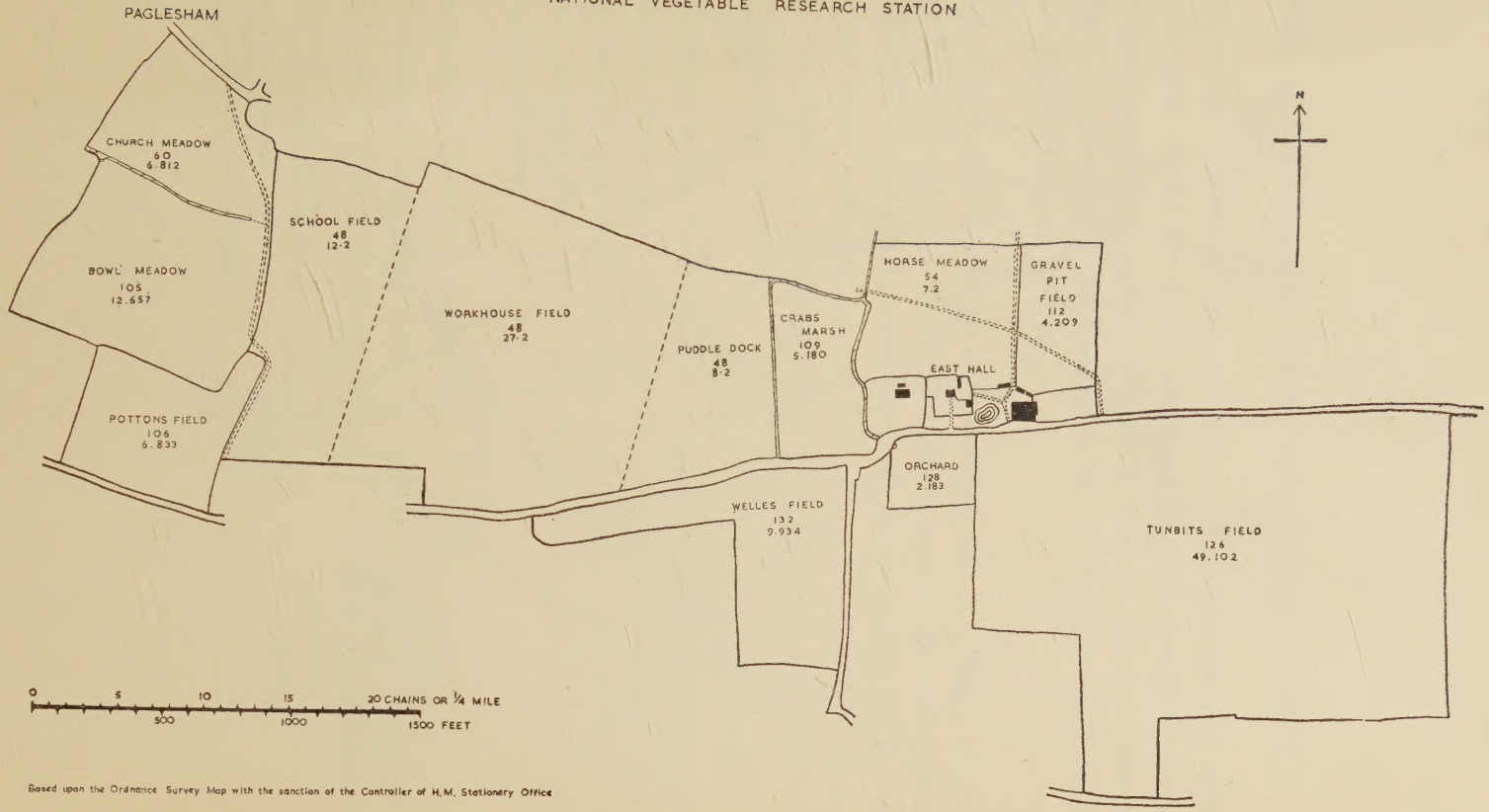


Based upon the Ordnance Survey Map with the sanction of the Controller of H.M. Stationery Office

PAGLESHAM SUB-STATION

OF THE

NATIONAL VEGETABLE RESEARCH STATION



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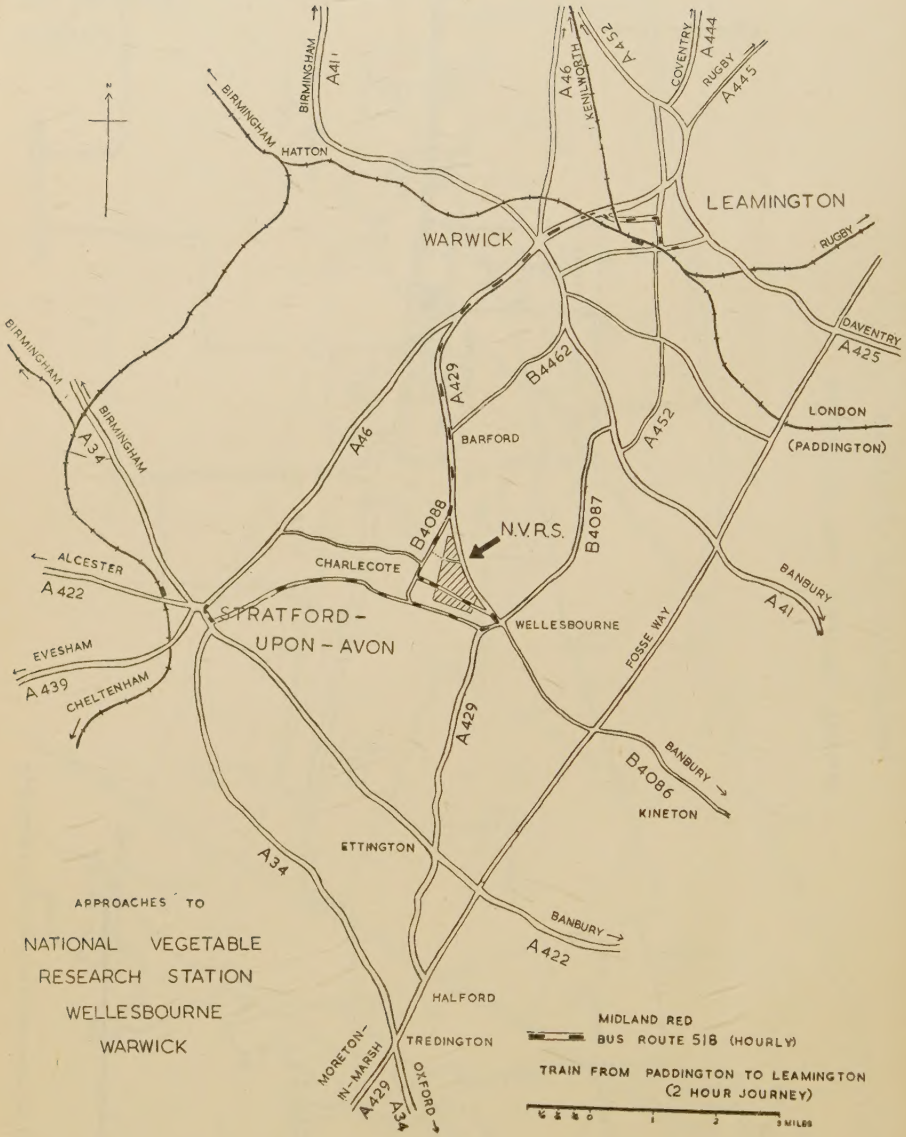
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B4462
BARFORD
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N.V.R.S.
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ALCESTER
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CHARLECOTE
STRATFORD-
UPON-AVON
WELLESBOURNE
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CHELTENHAM
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THE JOURNAL OF HORTICULTURAL SCIENCE

The Journal of Horticultural Science, which is sponsored by the Long Ashton Research Station and the East Malling Research Station, welcomes contributions on horticultural science from Research Institutes at home or abroad. Papers for publication and all communications should be sent to the Editor at East Malling Research Station, Maidstone, Kent.

Recent papers describe work on fruit, vegetables, hops and flowers, including cultural studies ; the effects of mineral deficiencies in various crops such as apple, broccoli, cacao, lettuce, potato, tomato, strawberry and bulbs ; fruit storage ; the biology and control of pests of fruit and their predators ; the control of fungous diseases, virus diseases, genetical studies of fruits and vegetables ; soil sterilisation ; weed control in vegetable crops.

The current Volume 33 will contain scientific papers on the growth and cropping of glasshouse tomato plants ; in particular there are studies of the effects of soil moisture, both on tomatoes under glass and on early turnips. A non-bolting strain of Detroit beet is described. There is also a description of an automatic device for the control of day-length.

The publishers are Messrs. Headley Bros., 109 Kingsway, London, W.C.2., to whom intending subscribers should apply. The subscription rates for Volume 33 are 60 shillings per volume (rate for Canada and the U.S.A. $8.50), or 20 shillings for a single number.